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Volume 9, Number 7, July 1968

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

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Tritium in Surface Waters of the United States, 1966

A. A. Moghissi and C. R. Porter¹

During 1964, a tritium sampling network was established by the Public Health Service to measure the levels and consequently to determine the public health significance of tritium in surface waters of the United States. The analytical procedures used are described. Data for the samples obtained are presented. A means for estimating the radiation dose resulting from tritium in the body is developed.

Tritium is a radionuclide possessing extraordinary properties. With a mass three times that of protium (the hydrogen isotope with the mass number one), tritium causes the highest known isotope effect. The low beta energy emission with a maximum of 18 keV requires special procedures for its detection and measurement. The public health significance of tritium arises from the fact that it can replace protium in the biological processes. Although the amount of tritium occurring in natural sources is small, the atmospheric testing of thermonuclear devices and the expanding nuclear industry have caused a considerable increase in the environmental levels of tritium.

During 1964, a Tritium Sampling Network was established by the Public Health Service to measure the levels, and consequently to determine the public health significance of tritium in surface waters of the United States. To obtain coverage of the major river basins, 10 stations were selected from the 131 existing water pollution surveillance sampling stations operated by the Federal Water Pollution Control Administration. Eight of these stations

are located downstream from nuclear facilities and the other two stations serve to establish baseline levels. The results of the initial study were published previously (1). Beginning in 1966, samples have been obtained from the Savannah River near Beaufort, S. C., and Augusta, Ga.; and the Broad River near Columbia, S. C. These three stations are part of the environmental surveillance program of the South Carolina State Board of Health, and include two stations located in the vicinity of the Savannah River Plant operated by E. I. du Pont de Nemours and Company for the Atomic Energy Commission. The locations of the sampling stations are given in table 1.

Analytical procedures

Composites of weekly grab samples (1 liter) of each calendar month are shipped in disposable containers for the Southeastern Radiological Health Laboratory for analysis. The samples are distilled, and 5-ml aliquots are taken for counting. Duplicate aliquots are mixed with 20 ml each of a scintillation solution of 7 grams 2,5-diphenyloxazole (PPO), 1.5 grams p-bis-(o-methystyryl)-benzene (bis-MSB), and 120 grams naphthalene per liter of dioxane. All operations involving the scintillation solution are carried out under red light. A Beckman

¹ Dr. Moghissi is chief, Physical Sciences and Mr. Porter is chief, Analytical Services, Southeastern Radiological Health Laboratory; Montgomery, Ala.

Table 1. Tritium concentration of surface waters in the United States, 1966*

Collection site	Concentration (nCi/liter)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Big Sioux River:												
Sioux Falls, S. D.....	<2.0	<2.0	4.9±0.5	<4.1	b	b	b	2.3±0.6	1.8±0.6	2.2±0.3	1.3±0.3	1.2±0.3
Clinch River:												
Kington, Tenn.....	8.0±1.8	<2.0	22.3±0.7	<4.1	5.4±4.1	b	2.6±0.6	2.3±0.6	1.2±0.6	3.4±0.4	2.9±0.3	2.9±0.3
Colorado River:												
Boulder City, Nev.....	5.9±2.0	<2.0	7.9±0.4	<4.1	<4.1	b	4.2±0.5	4.3±0.5	3.3±0.6	4.2±0.4	3.5±0.4	3.1±0.3
Columbia River:												
Northport, Wash.....	<2.0	<2.0	4.2±0.5	<4.1	<4.1	b	3.7±0.6	2.1±0.6	2.4±0.6	3.5±0.4	2.9±0.3	1.9±0.3
Pasco, Wash.....	<2.0	2.1±2.0	6.8±0.6	<4.1	5.3±4.1	b	2.8±0.7	3.4±0.5	2.3±0.6	3.1±0.4	2.6±0.3	2.1±0.3
Hudson River:												
Poughkeepsie, N. Y.....	<2.0	2.5±2.0	5.1±0.5	<4.1	<4.1	b	2.9±0.7	2.8±0.7	2.0±0.6	2.9±0.3	1.7±0.3	1.4±0.3
Mississippi River:												
New Orleans, La.....	<2.0	<2.0	2.4±0.6	<4.1	<4.1	b	2.4±0.6	3.2±0.6	1.5±0.6	2.6±0.3	1.7±0.3	1.4±0.3
Ohio River:												
Toronto, Ohio.....	2.2±2.0	b	b	<4.1	b	b	2.9±0.7	b	1.9±0.6	3.2±0.4	b	b
Rio Grande:												
El Paso, Tex.....	<2.0	<2.0	4.0±0.5	<4.1	<4.1	b	2.8±0.7	3.5±0.7	1.3±0.6	1.9±0.3	0.7±0.3	b
Savannah River:												
Port Wentworth, Ga.....	32.0±2.1	10.9±1.7	6.2±0.5	13.8±4.1	5.2±4.1	b	14.0±0.7	8.5±0.5	12.8±0.4	7.3±0.3	8.6±0.4	9.6±0.4
Beaufort, S. C.....	5.4±1.6	b	b	b	b	8.6±0.4	8.8±0.6	9.0±0.6	b	13.0±0.4	8.1±0.4	12.5±0.5
Augusta, Ga.....	<2.0	b	b	b	b	2.2±0.6	8.8±0.6	9.0±0.6	b	13.0±0.4	8.1±0.4	12.5±0.5
Broad River:												
Columbia, S. C.....	<2.0	b	b	b	b	1.4±0.6	1.8±0.6	1.5±0.6	b	1.3±0.6	2.6±0.3	1.4±0.3

* Minimum limits of detectability were:
 January-February, 2 nCi/liter
 March, June-December, 0.6 to 0.3 nCi/liter (see text)
 April-May, 4.1 nCi/liter
 b No sample received.

liquid scintillation counting system is used. A background sample is counted with each of the duplicates and a standard is counted between the duplicates. The counting time is 100 minutes. Details of the procedure are given by Moghissi, et al (2).

January and February samples were analyzed by procedures described previously (1), with a minimum limit of detectability of 2 nCi/liter. March and June-December 1966 samples were analyzed according to the procedures described above. Improvements in sample preparation during this time decreased the minimum limit of detectability from 0.6 to 0.2 nCi/liter. April and May samples were analyzed by the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio, with a minimum limit of detectability of 4.1 nCi/liter.

Results

Data for the samples collected during 1966 are presented in table 1. The values are associated with the stated counting errors at 2 σ confidence level. As expected, there is a large variation in the tritium concentrations of the surface waters; the largest variation is found in rivers near large nuclear installations. Because of differences in methods utilized throughout the year, no attempt was made to determine an average concentration.

Radiation dose to the population

The radiation dose resulting from tritium in the body can be estimated by using the relationship between the body burden q (in μ Ci) and R (in rem/week) recommended by the International Commission for Radiological Protection (ICRP) (3):

$$q = \frac{2.8 \times 10^{-3} m \cdot R}{f_2 \epsilon} \quad (1)$$

where m is the mass of the organ of reference (in this case, $m = 70$ kg, the mass of the total body), f_2 is the fraction of the body burden in the organ of reference (equal to 1 for tritium), and ϵ is the effective absorbed energy per disintegration of the radionuclide (equal to 0.01 MeV for tritium). Although Shtukkenberg (4) proposed an RBE factor (6) of 3 for beta emitters with the maximum energy of less than 60 keV, experiments with tritiated thymidine (5) have introduced more uncertainties regarding the RBE factor for tritium. A value of 1.7 (3) has been used for the present calculations, in accordance with recommendations of ICRP.

If R is expressed in millirem/year, then equation (1) becomes

$$R = 2.65 q \quad (2)$$

The hydrogen content of the standard man is 7,000 grams (3), which if oxidized would result in 83 liters of water. Assuming an even distribution of tritium in the body, and following the recommendations of the International Commission on Radiological Units and Measurements, (ICRM) (6), replacing R by DE [Dose Equivalent] equation (2) results in the following relationship:

$$DE \text{ (mrem/yr)} = 0.17 C \text{ (nCi/liter)} \quad (3)$$

where C represents the tritium concentration in the body in nCi/liter of water.

In estimating radiation dose to the public based on observed tritium concentrations in surface water, it is assumed that the concentration of tritium in all water taken into the body is equal to that found in surface water, and that the specific activity of tritium in the body is essentially the same as that in the surface water. Furthermore, it is assumed that a change in the concentration of tritium in the water will produce a corresponding body change in a relatively short period of time. The latter assumption is justified by the short (around 12 days) biological half-life of tritium (5).

Based on the range of concentrations of tritium in surface waters, the expected average values for C are between 2 and 15 nCi/liter, which correspond to a whole-body dose to the general population of between 0.3 and 2.5 millirem/year. In terms of Federal Radiation Council guidance, this represents 0.2 to 1.5 percent of the Radiation Protection Guide (170 mrem/year) for an average dose to a suitable sample of the population (7).

It is of particular interest to estimate the contribution of tritium from a major nuclear installation to the radiation exposure of the public. For example, it may be seen that the increase in tritium concentration in the Savannah River between Augusta, Ga., and Beaufort, S. C., following the discharge from the Savannah River Plant is in the range of 6 to 10 nCi/liter. Inasmuch as Beaufort receives its drinking water primarily from the Savannah River, this tritium concentration corresponds to an estimated whole-body dose of 1.0

to 1.7 mrem/year, or in terms of Federal Radiation Council guidance, 0.6 to 1.0 percent of the Radiation Protection Guide for an average dose to a suitable sample of the population (7).

It should be emphasized that the above calculated doses apply only to the areas sampled and cannot necessarily be extrapolated to other locations.

Acknowledgment

The authors wish to express their appreciation for the technical assistance of Mrs. Mae W. Williams and Miss Rachael H. Gorrie in performing the laboratory experiments, and Mrs. Ann B. Strong in the preparation of this paper.

Mention of commercial products used in connection with work reported in this article does not constitute an endorsement by the Public Health Service, and the Department of Health, Education, and Welfare.

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Tritiated Moisture in the Atmosphere Surrounding a Nuclear Fuel Reprocessing Plant¹

J. C. Daly, A. V. Manchester, J. J. Gabay and N. I. Sax²

A new wide-area sampling technique was used to collect more than 700 tritiated moisture samples over a 2-month period from seven sampling legs radiating out from a nuclear fuel reprocessing plant. For the 28 sampling periods studied, the average tritium radioactivity on the sampling leg northwest of the plant exceeded 2,500 pCi/liter, 75 percent of the time and exceeded 10,000 pCi/liter, 39 percent of the time as opposed to ambient levels of <2,500 pCi/liter. The highest tritium level recorded was 26,400 pCi/liter. These data are reported not so much for their epidemiologic value as for their value to public health agencies contemplating radiological surveillance around nuclear facilities.

The nuclear fuel reprocessing plant, Nuclear Fuel Services, Inc. (NFS), located in western New York State, about 30 miles south of Buffalo, has been operational for approximately 2 years. One of the radionuclides it releases into the environment is tritium. It has been estimated that about 200 curies of tritium per day will be released during the reprocessing of spent fuel elements (1). Of this, 25 percent is released via the stack, 65 percent via liquid discharge into Buttermilk Creek and the remaining 10 percent goes to waste storage.

In order to determine the dispersion pattern and to relate the amount of tritium discharged to levels of tritium in atmospheric moisture, an intensive study of the area surrounding the plant was undertaken during the summer of 1967. A secondary goal was the evaluation of a new sampling technique for tritiated moisture.

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² Mr. Daly is a senior chemist with the Radiological Sciences Laboratory, New York State Health Department; Mr. Manchester is a field research scientist with Health Research, Inc., New York State Health Department; Mr. Gabay is senior research scientist, and Mr. Sax, associate research scientist, both with Radiological Sciences Laboratory, Division of Laboratories and Research, New York State Health Department, Albany, N.Y. 12206.

Relatively little information is available concerning the levels of tritium released into the atmosphere by nuclear facilities. Most atmospheric surveillance programs encompass only gross beta measurements (2-4). Schmidt (5) fails to mention it as a constituent of the effluent. Monitoring of the atmosphere for tritium is briefly mentioned in Monsanto Research Corporation's environmental monitoring reports (6-7), but these reports state only that tritium levels were below the limit of detection.

Sampling method

The device used to collect tritiated moisture samples has been previously described in detail (8). Briefly, it consists of 200 g of silica gel in a plastic-screen bag. The unit is placed in a mason jar, sealed and shipped to the field where the silica gel bag is removed, suspended from a convenient overhang and allowed to extract moisture from the air. At the end of the sampling period it is replaced in the mason jar, which is sealed, and returned to the laboratory for tritium analysis.

Sampling legs (figure 1) were established which radiated from the plant with the stack as origin. The sampling points on each sam-

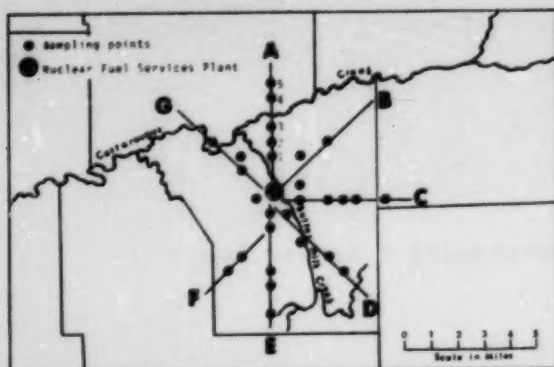


Figure 1. Sampling points for tritiated moisture surrounding NPS site

pling leg were numerically identified with the lowest numerical value assigned to the point closest to the plant as shown for leg A in figure 1. The sampling period was 48 hours of exposure of the silica gel sampler to the atmosphere. This method of sampling food affords two important advantages.

First, it allows large scale sampling with a minimum of difficulty. The only requirement is that the samplers must be distributed and then collected at the end of the sampling period. No power source, complicated equipment or measuring devices are necessary. The only limitation is the total distance involved in the placement and collection of the samples along the sampling network. The ability to do large scale sampling is a marked advantage in the determination of a dispersion pattern.

A second advantage to this sampling technique is the elimination of many of the uncertainties usually associated with the measurement of such parameters as air flow rate and collection efficiency which are necessary to compute tritium concentration in terms of radioactivity per unit volume. To delineate a distribution pattern, it is only necessary to compare the tritium content of the water vapor at one sampling point to that at other sampling points. Consequently, we need not concern ourselves with any sampling parameters other than perhaps the sampling period which is of interest only because we want to compare measurements taken within a given time interval.

Analytical method

Liquid scintillation counting techniques as described by Butler (9) are used, with slight modification. The sample is not enriched. Samples are vacuum distilled and 3 ml of the distillate are mixed with 17 ml of scintillator. Standard and background samples are prepared in the same manner as by Butler except these samples are not distilled. Background samples consisting of 3 ml of low tritium content water (3 pCi/liter) mixed with 17 ml of scintillator are used.

A Beckman liquid scintillation counting system (model LS-200 B) was used at a counting efficiency for tritium of 28 percent. Background counting rates are about 13-14 cpm. Based on a counting efficiency of 28 percent, a background of 13.5 cpm, a counting time of 100 minutes for sample and 300 minutes for background, and a 3 ml sample, the sensitivity for the Beckman system is 500 pCi/liter $\pm$ 100 percent at the 95-percent confidence level. Figure 2 shows the relationship between counting error and specific activity of the sample. It

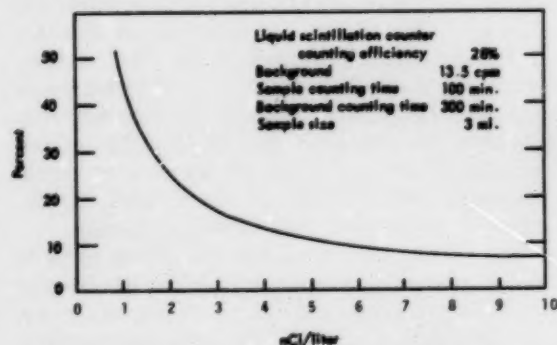


Figure 2. Counting error vs. level of tritium activity

should be noted that at tritium levels above 1,000 pCi/liter, the counting error is less than $\pm$ 50 percent. Above 5,000 pCi/liter, the counting error is reduced to 10 percent or less. The majority of water vapor samples analyzed were greater than 1,000 pCi/liter.

Discussion

Over 700 samples were collected on seven sampling legs during a 2-month period. The

Table 1. Tritium levels on sampling leg A (north of NFS)

Sampling dates	Concentration (nCi/liter)				
	Tritium levels at sampling points				
	A-1 (1.5)*	A-2 (2.0)	A-3 (2.5)	A-4 (3.3)	A-5 (4.0)
7/17-7/19	2.3	2.6	2.6	2.2	NS
7/19-7/21	3.2	2.1	2.4	2.4	NS
7/21-7/23	4.6	1.7	2.1	1.4	NS
7/23-7/25	2.0	.9	1.3	1.0	NS
7/25-7/27	2.0	3.3	2.6	2.3	1.6
7/27-7/29	3.2	6.6	2.6	2.2	2.1
7/29-7/31	9.6	2.7	1.4	NS	1.7
7/31-8/02	1.6	4.0	2.7	2.3	2.4
8/02-8/06	3.4	1.3	1.2	1.2	NS
8/06-8/08	3.3	NS	1.9	2.3	1.5
8/08-8/10	1.8	1.2	1.5	NS	NS
8/10-8/12	1.9	1.9	1.3	1.8	NS
8/12-8/14	4.8	2.2	2.1	1.8	1.6
8/14-8/16	3.2	1.8	1.5	1.1	1.5
8/16-8/18	3.7	1.4	1.3	1.1	1.5
8/18-8/22	NS	1.7	1.2	1.5	2.4
8/22-8/26	1.5	1.4	1.2	1.2	1.4
8/26-8/30	3.2	1.9	2.4	1.8	1.7
8/30-9/05	19.6	6.4	4.0	4.6	4.5
9/05-9/07	5.3	1.3	1.8	1.9	2.9
9/07-9/09	2.3	.9	1.9	1.1	.6
9/09-9/11	3.6	1.7	.8	1.2	2.0
9/11-9/13	1.4	2.1	1.9	1.5	1.3
9/13-9/15	5.5	1.6	1.4	1.5	1.7
9/15-9/17	1.4	.5	.5	.7	NS
9/17-9/19	6.8	2.0	1.6	3.1	2.5
9/19-9/21	.7	.2	.5	.8	.6
9/21-9/23	1.8	1.7	.6	.6	1.0

* Figures in parentheses indicate the number of miles from NFS.
NS, no sample collected.

study began in July 1967 and ran through the middle of September 1967. Tables 1 to 7 present the tritium radioactivity at each sampling point for all sampling legs for this 2-month span. Present ambient levels of tritium are about 200-1,000 pCi/liter for atmospheric moisture or precipitation (10), due to cosmic ray produced tritium and tritium resulting from nuclear weapons testing (11).

On this basis one can assume that tritium radioactivity in excess of these values can be attributed to tritium locally injected into the atmosphere in the area of the NFS site. It can readily be seen that the tritium radioactivity is generally higher in this area than in nonindustrial localities.

If one takes 2,500 pCi/liter as an arbitrary cutoff, analysis of the average tritium radioactivity (table 8) per sampling leg for all sampling periods yields the number of occurrences of radioactivity above this level for each sampling leg. In 21 cases out of 28, the tritium radioactivity in water vapor exceeds 2,500 pCi/liter on sampling leg G. Sampling legs A and E have a frequency of about 20 percent as com-

Table 2. Tritium levels on sampling leg B (northeast of NFS)

Sampling dates	Concentration (nCi/liter)		
	Tritium levels at sampling points		
	B-1 (1.3)*	B-2 (2.3)	B-3 (3.3)
7/17-7/19	3.7	2.1	2.0
7/19-7/21	1.9	NS	1.4
7/21-7/23	1.9	1.6	1.2
7/23-7/25	1.3	NS	1.9
7/25-7/27	1.6	NS	2.5
7/27-7/29	1.9	2.3	1.4
7/29-7/31	9.1	2.3	2.1
7/31-8/02	2.3	2.7	1.7
8/02-8/06	1.9	1.3	1.6
8/06-8/08	1.8	1.8	1.7
8/08-8/10	2.5	1.8	1.4
8/10-8/12	1.8	1.6	1.7
8/12-8/14	1.7	2.6	1.4
8/14-8/16	2.5	1.3	1.3
8/16-8/18	3.3	1.6	1.6
8/18-8/22	3.4	2.2	1.9
8/22-8/26	.8	.9	1.3
8/26-8/30	2.5	2.9	1.5
8/30-9/05	2.1	1.7	NS
9/05-9/07	1.6	2.2	1.6
9/07-9/09	1.6	1.3	.7
9/09-9/11	1.9	1.4	
9/11-9/13	1.6	1.7	1.4
9/13-9/15	NS	1.2	.8
9/15-9/17	1.1	1.0	.5
9/17-9/19	1.6	.9	1.0
9/19-9/21	.4	NS	.9
9/21-9/23	.8	NS	.8

* Figures in parentheses indicate the number of miles from NFS.
NS, no sample collected.

Table 3. Tritium levels on sampling leg V (east of NFS)

Sampling dates	Concentration (nCi/liter)				
	Tritium levels at sampling points				
	C-1 (1.3)*	C-2 (1.8)	C-3 (2.4)	C-4 (2.8)	C-5 (3.4)
7/17-7/19	2.0	2.2	1.9	1.4	NS
7/19-7/21	1.6	1.9	1.4	1.1	NS
7/21-7/23	2.0	1.6	1.4	1.3	NS
7/23-7/25	0.4	1.6	9.8	1.1	NS
7/25-7/27	1.9	3.7	3.0	1.8	2.0
7/27-7/29	2.2	2.2	1.7	2.2	1.5
7/29-7/31	2.4	2.4	1.2	2.1	1.7
7/31-8/02	2.0	NS	2.0	2.6	2.2
8/02-8/06	2.1	2.4	1.6	1.4	1.5
8/06-8/08	1.7	1.5	1.8	1.6	1.7
8/08-8/10	2.7	2.8	1.8	1.4	1.3
8/10-8/12	2.3	1.7	1.2	1.7	1.8
8/12-8/14	1.4	1.7	1.4	1.4	1.1
8/14-8/16	1.7	2.0	1.6	1.3	1.7
8/16-8/18	1.0	1.0	1.0	1.1	1.0
8/18-8/22	1.5	1.1	1.3	1.6	1.3
8/22-8/26	1.3	1.8	.7	1.0	.8
8/26-8/30	2.1	NS	1.3	1.1	1.3
8/30-9/05	2.3	2.0	2.0	1.7	1.6
9/05-9/07	1.7	1.7	1.3	1.7	1.9
9/07-9/09	1.0	1.0	1.2	1.2	1.0
9/09-9/11	1.8	1.0	1.4	1.8	1.1
9/11-9/13	1.6	.9	1.0	.8	1.5
9/13-9/15	0.9	1.2	.4	1.2	1.4
9/15-9/17	2.2	1.0	1.3	1.1	.7
9/17-9/19	1.7	.7	.8	.9	1.0
9/19-9/21	.5	1.0	NS	.5	.3
9/21-9/23	2.0	2.6	1.5	0.6	1.1

* Figures in parentheses indicate the number of miles from NFS.
NS, no sample collected.

Table 4. Tritium levels on sampling leg D (southeast of NFS)

Sampling dates	Concentration (nCi/liter)		
	Tritium levels at sampling points		
	D-2 (1.5)*	D-3 (2.7)	D-4 (3.4)
7/17-7/19	1.6	2.2	2.0
7/19-7/21	2.3	1.7	1.9
7/21-7/23	1.9	1.2	1.4
7/23-7/25	1.0	.8	1.1
7/25-7/27	1.6	1.3	1.8
7/27-7/29	2.1	NS	1.7
7/29-7/31	2.2	1.9	1.9
7/31-8/02	2.1	1.8	2.1
8/02-8/06	2.0	2.2	NS
8/06-8/08	1.4	1.2	1.9
8/08-8/10	3.4	2.1	2.0
8/10-8/12	4.1	2.1	2.1
8/12-8/14	1.9	1.9	1.7
8/14-8/16	1.6	1.3	2.2
8/16-8/18	1.3	1.6	1.4
8/18-8/22	1.4	1.2	1.0
8/22-8/26	1.4	.6	.8
8/26-8/30	1.5	1.3	2.1
8/30-9/05	2.6	2.9	1.9
9/05-9/07	2.5	2.1	1.3
9/07-9/09	1.6	.6	NS
9/09-9/11	1.2	1.1	1.3
9/11-9/13	1.6	1.6	1.3
9/13-9/15	1.8	1.9	1.3
9/15-9/17	.8	1.1	1.4
9/17-9/19	2.2	NS	2.0
9/19-9/21	1.1	.8	.5
9/21-9/23	2.5	1.7	NS

* Figure in parentheses indicates the number of miles from NFS.
NS, no sample collected.

pared to 75 percent for leg G. The lowest levels appeared along leg C, where average tritium level never exceeded 2,500 pCi/liter. The dispersion pattern of tritiated atmospheric moisture in the area is readily discernible.

Summary

It was demonstrated that the sampling technique was well suited to the type of study undertaken. Quantitative information on tritium levels in atmospheric moisture and dispersion patterns for tritiated atmospheric moisture were obtained for the fuel reprocessing site. It is recognized that much more of such work needs to be done. Further studies will attempt to determine the contributions of local sources of HTO, followed by correlation of meteorological data to dispersion patterns.

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Table 5. Tritium levels on sampling leg E (south of NFS)

Sampling dates	Concentration (mCi/liter)				
	Tritium levels at sampling points				
	E-1 (0.5)*	E-2 (1.0)	E-3 (2.4)	E-4 (3.1)	E-5 (4.0)
7/17-7/19	NS	NS	NS	NS	NS
7/19-7/21	NS	NS	NS	NS	NS
7/21-7/23	NS	NS	NS	NS	NS
7/23-7/25	NS	NS	NS	NS	NS
7/25-7/27	1.7	1.4	1.8	1.8	1.7
7/27-7/29	1.6	1.5	1.7	1.4	0.7
7/29-7/31	1.9	1.9	1.5	1.4	1.0
7/31-8/02	2.2	1.5	1.8	2.0	1.6
8/02-8/06	0.6	6.4	1.9	1.6	1.7
8/06-8/08	2.2	2.2	1.3	1.2	2.1
8/08-8/10	0.2	1.7	1.0	1.2	1.2
8/10-8/12	10.0	6.0	2.5	2.2	1.6
8/12-8/14	17.0	6.7	1.4	1.4	1.6
8/14-8/16	2.0	1.5	1.3	NS	1.4
8/16-8/18	1.2	1.3		.9	1.1
8/18-8/22	1.5	1.2	1.8	1.1	1.3
8/22-8/26	2.8	2.3	1.0	1.1	1.3
8/26-8/30	1.0	NS	NS	1.3	1.3
8/30-9/03	3.9	NS	1.5	1.7	1.4
9/03-9/07	3.3	NS	2.0	NS	NS
9/07-9/09	9.6	8.1	1.8	1.9	1.0
9/09-9/11	NS	NS			
9/11-9/13	5.8	2.5	1.7	1.1	1.3
9/13-9/15	2.9	1.7	1.2	0.9	1.2
9/15-9/17	NS	NS	.8	2.0	1.2
9/17-9/19	3.7	2.2	.9	0.4	0.7
9/19-9/21	2.4	1.8	1.5	1.1	1.6
9/21-9/23	.4	.0	.7	NS	1.1
	.7	1.0	.9	1.3	1.2

* Figures in parentheses indicate the number of miles from NFS.
NS, no sample collected.

Table 6. Tritium levels on sampling leg F (southwest of NFS)

Sampling dates	Concentration (mCi/liter)	
	Tritium levels at sampling points	
	F-1 (2.3)*	F-2 (3.0)
7/17-7/19	1.2	1.3
7/19-7/21	0.9	1.1
7/21-7/23	1.3	2.2
7/23-7/25	.9	.8
7/25-7/27	1.7	1.8
7/27-7/29	1.5	1.6
7/29-7/31	1.6	1.6
7/31-8/02	1.3	2.3
8/02-8/06	2.2	2.0
8/06-8/08	1.9	2.1
8/08-8/10	.9	.9
8/10-8/12	2.7	2.6
8/12-8/14	2.7	2.6
8/14-8/16	NS	1.3
8/16-8/18	1.3	1.1
8/18-8/22	.8	1.2
8/22-8/26	.4	1.1
8/26-8/30	.8	1.0
8/30-9/03	1.6	1.1
9/03-9/07	1.8	3.8
9/07-9/09	2.3	1.1
9/09-9/11	1.5	2.3
9/11-9/13	NS	2.1
9/13-9/15	1.0	1.9
9/15-9/17	1.0	.6
9/17-9/19	1.6	1.1
9/19-9/21	.3	.8
9/21-9/23	1.4	.5

* Figures in parentheses indicate the number of miles from NFS.
NS, no sample collected.

Table 7. Tritium levels on sampling leg G (northwest of NFS)

Sampling dates	Concentration (mCi/liter)			
	Tritium levels at sampling points			
	G-1 (0.5)*	G-2 (1.3)	G-3 (1.6)	G-4 (2.8)
7/17-7/19	1.9	13.8	8.2	3.4
7/19-7/21	7.2	11.7	7.8	3.7
7/21-7/23	5.5	4.8	5.7	1.8
7/23-7/25	.7	1.2	1.4	1.0
7/25-7/27	1.5	1.7	6.2	6.4
7/27-7/29	4.1	3.8	3.9	5.3
7/29-7/31	3.7	6.9	12.7	8.9
7/31-8/02	3.6	9.2	7.2	7.8
8/02-8/06	8.5	13.2	16.5	8.6
8/06-8/08	6.5	10.3	8.1	5.9
8/08-8/10	1.0	2.0	1.8	1.9
8/10-8/12	4.9	4.0	5.6	3.2
8/12-8/14	9.9	6.6	12.5	3.7
8/14-8/16	2.9	11.2	7.0	3.8
8/16-8/18	3.4	2.6	2.2	3.5
8/18-8/22	3.9	3.7	3.5	4.7
8/22-8/26	4.6	NS	5.4	4.3
8/26-8/30	3.2	10.5	5.2	2.6
8/30-9/03	5.4	2.8	2.6	8.6
9/03-9/07	3.7	3.0	3.6	4.3
9/07-9/09	1.2	1.4	.9	1.4
9/09-9/11	13.0	9.9	7.3	3.5
9/11-9/13	6.4	7.5	15.9	4.5
9/13-9/15	4.9	13.4	26.4	12.9
9/15-9/17	3.2	4.5	3.2	1.5
9/17-9/19	3.8	1.8	3.7	3.1
9/19-9/21	.7	.9	NS	.8
9/21-9/23	.8	.7	1.1	1.2

* Figures in parentheses indicate the number of miles from NFS.
NS, no sample collected.

Table 8. Average tritium radioactivity for each sampling leg
(concentration, nCi/liter)

Sampling dates	Sampling leg and direction from NFS						
	A	B	C	D	E	F	G
	(North)	(Northeast)	(East)	(Southeast)	(South)	(Southwest)	(Northwest)
7/17-7/19	2.4	2.6	1.9	2.0	NS	1.2	6.8
7/19-7/21	2.5	1.6	1.5	2.0	NS	1.0	7.6
7/21-7/23	2.4	1.6	1.6	1.5	NS	1.7	4.4
7/23-7/25	1.3	1.6	.8	1.0	NS	.9	1.1
7/25-7/27	2.4	2.1	2.5	1.6	1.7	1.7	4.0
7/27-7/29	3.3	1.9	2.0	1.9	1.4	1.5	4.3
7/29-7/31	3.8	4.5	2.0	2.0	1.5	1.6	8.0
7/31-8/02	2.6	2.2	2.2	2.0	1.8	1.8	7.0
8/02-8/06	1.8	1.6	1.8	2.1	4.2	2.1	10.9
8/06-8/08	2.3	2.0	1.6	1.5	1.8	2.0	7.7
8/08-8/10	1.5	1.9	2.0	2.5	1.1	.9	1.7
8/10-8/12	1.7	1.7	1.7	2.8	4.5	2.6	4.4
8/12-8/14	2.5	1.9	1.4	1.5	5.6	2.6	8.2
8/14-8/16	1.8	1.7	1.6	1.7	1.6	1.3	6.2
8/16-8/18	1.8	2.2	1.0	1.5	1.1	1.2	2.9
8/18-8/22	1.7	2.5	1.4	1.2	1.4	.9	3.7
8/22-8/26	1.4	1.0	1.1	.9	1.7	.8	4.8
8/26-8/30	2.2	2.3	1.4	1.4	1.2	.9	5.4
8/30-9/06	7.6	1.9	1.9	2.5	2.1	1.4	4.9
9/06-9/07	2.7	1.8	1.7	2.2	2.7	2.7	4.2
9/07-9/09	1.3	1.2	1.1	1.2	4.1	1.7	1.2
9/09-9/11	1.9	1.6	1.4	1.2	2.5	1.0	8.4
9/11-9/13	2.2	1.5	1.2	1.5	1.6	1.6	8.6
9/13-9/15	2.3	1.0	1.0	1.7	1.3	1.7	14.1
9/15-9/17	.8	.8	1.2	.8	1.6	.8	3.1
9/17-9/19	3.2	1.1	1.0	2.1	1.8	1.4	2.8
9/19-9/21	.6	.7	.5	.8	.6	.5	.6
9/21-9/25	1.1	.8	1.6	2.1	1.0	1.0	.9

NS, no sample collected.

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SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Federal and State agencies are involved in efforts to monitor continuously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained by radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Fresh milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, fresh milk is the single food item most often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of fresh milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (1-3). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of

exposure (3). Additional guidelines are provided by the FRC Protective Action Guides (4) and by the International Commission on Radiological Protection (5,6).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide

levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program
Radiostrontium in milk, HASL

Period reported
July-December 1966

Last presented
September 1967

1. Pasteurized Milk Network March 1968

*National Center for Radiological Health
and National Center for Urban and
Industrial Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) is designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, Washington, D.C., the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the

PMN appeared in the January 1968 issue of *Radiological Health Data and Reports* (1); the February 1968 issue (2) introduced several changes in the interpretation and reporting of data.

Table 1. Analytical errors associated with determinations of radionuclide concentrations in a milk sample

Nuclide	Concentration (pCi/liter)	Error ^a (pCi/liter)	Concentration (pCi/liter)	Error ^a (percent of concentration)
Strontium-89	<50	5	≥50	10
Strontium-90	<20	2	≥20	10
Iodine-131	<100	10	≥100	10
Cesium-137	<100	10	≥100	10
Barium-140	<100	10	≥100	10

^a Two standard deviations.

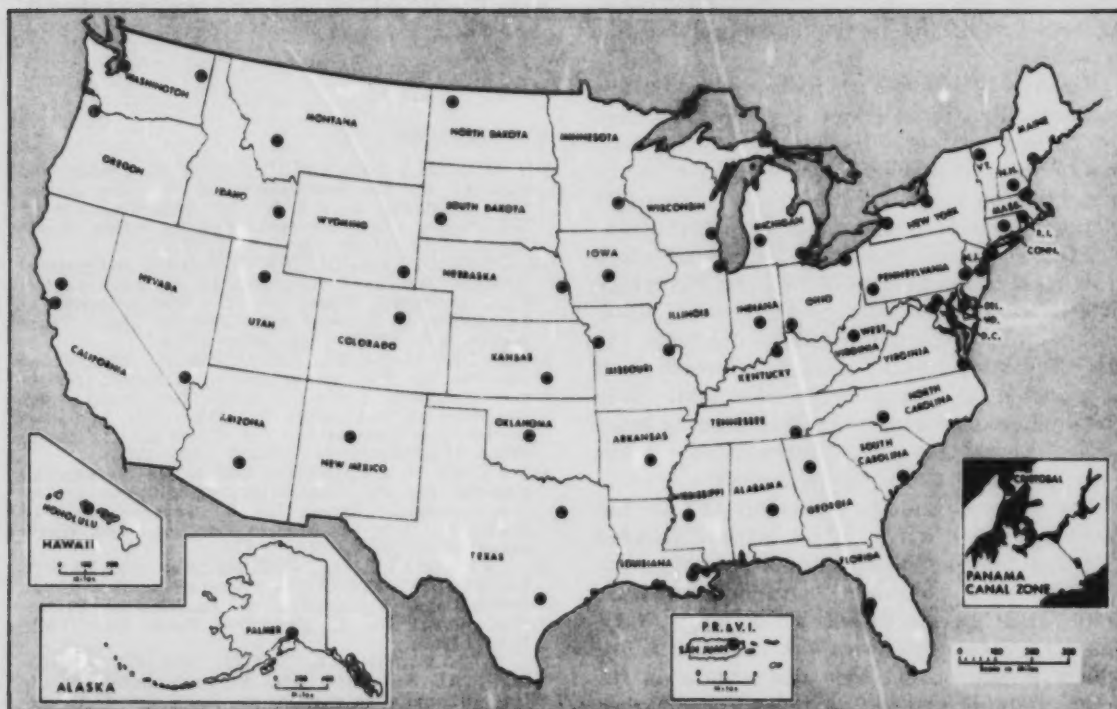


Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentrations of radionuclides in pasteurized milk for March 1968 and the 12-month period, April 1967-March 1968^a

Sampling location		Radionuclide concentration (pCi/liter)									
		Strontium-90		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		Apr 1967-Mar 1968	March 1968	Apr 1967-Mar 1968	March 1968	Apr 1967-Mar 1968	March 1968	Apr 1967-Mar 1968	March 1968	Apr 1967-Mar 1968	March 1968
Ala:	Montgomery	0	0	10	11	0	0	14	15	0	0
Alaska:	Palmer	1	0	6	5	0	0	18	13	1	0
Aris:	Phoenix	0	0	2	2	0	0	2	6	0	0
Ark:	Little Rock	0	0	22	19	0	0	10	18	0	0
Calif:	Sacramento	2	0	3	6	0	0	6	11	1	0
	San Francisco	2	3	3	4	0	0	4	5	1	0
C. Z:	Cristobal	0	0	3	0	0	0	10	5	0	0
Colo:	Denver	1	0	6	4	1	0	6	0	0	0
Conn:	Hartford	NA	NA	7	7	0	0	10	10	0	0
Del:	Wilmington	NA	NA	11	9	0	0	10	1	0	0
D. C:	Washington	0	0	10	9	0	0	7	6	0	0
Fla:	Tampa	0	0	8	9	0	0	72	57	0	0
Ga:	Atlanta	0	0	15	12	0	0	22	23	0	0
Hawaii:	Honolulu	0	0	3	3	0	0	6	0	0	0
Idaho:	Idaho Falls	1	0	6	4	0	0	8	8	0	0
Ill:	Chicago	0	0	9	7	0	0	12	5	0	0
Ind:	Indianapolis	NA	NA	7	9	0	0	8	4	0	2
Iowa:	Des Moines	1	0	8	6	0	0	8	8	0	0
Kans:	Wichita	2	3	8	6	0	0	4	6	0	0
Ky:	Louisville	0	0	12	12	0	0	26	23	0	0
La:	New Orleans	0	0	23	21	0	0	32	24	0	0
Maine:	Portland	NA	NA	11	7	0	0	8	4	0	0
Md:	Baltimore	0	0	10	10	0	0	27	21	0	0
Mass:	Boston	0	0	11	10	0	0	27	21	0	0
Mich:	Detroit	NA	NA	9	9	0	0	13	13	0	0
	Grand Rapids	NA	NA	10	8	0	0	17	10	0	2
Minn:	Minneapolis	1	0	12	8	0	0	14	13	0	0
Miss:	Jackson	0	0	18	18	0	0	16	7	1	2
Mo:	Kansas City	2	0	8	8	0	0	4	6	0	0
	St. Louis	2	2	10	8	0	0	7	6	0	0
Mont:	Helena	1	0	6	6	0	0	8	5	0	3
Nebr:	Omaha	1	0	8	8	0	0	6	5	0	0
Nev:	Las Vegas	0	0	3	3	0	0	11	11	0	0
N. H:	Manchester	NA	NA	13	11	0	0	30	24	0	0
N. J:	Trenton	NA	NA	9	8	0	0	11	6	0	0
N. Mex:	Albuquerque	0	0	2	2	0	0	2	5	0	0
N. Y:	Buffalo	NA	NA	8	7	0	0	12	9	0	0
	New York City	NA	NA	10	7	0	0	14	15	0	0
	Syracuse	NA	NA	7	6	0	0	11	8	0	0
N. C:	Charlotte	0	0	16	14	1	0	14	13	0	0
N. Dak:	Minot	3	3	12	10	0	0	13	10	0	0
Ohio:	Cincinnati	NA	NA	9	9	0	0	7	10	0	0
	Cleveland	NA	NA	9	7	0	0	11	3	0	0
Okla:	Oklahoma City	0	0	10	10	0	0	5	3	0	0
Ore:	Portland	2	0	7	6	1	0	15	14	0	0
Pa:	Philadelphia	NA	NA	9	8	0	0	9	5	0	0
	Pittsburg	NA	NA	12	9	0	0	16	11	0	0
P. H:	San Juan	0	0	5	4	0	0	13	14	0	0
R. I:	Providence	NA	NA	10	7	0	0	21	16	0	0
S. C:	Charleston	0	0	15	13	0	0	20	23	0	0
S. Dak:	Rapid City	2	3	11	6	0	0	11	8	0	0
Tenn:	Chattanooga	0	0	15	13	0	0	14	11	0	0
	Memphis	0	0	12	10	0	0	5	9	0	0
	Memphis	0	0	4	4	0	0	4	9	0	0
Tex:	Austin	0	0	8	8	0	0	6	9	0	0
	Dallas	1	1	5	4	0	0	12	12	0	0
Utah:	Salt Lake City	0	0	10	11	0	0	14	8	0	0
Va:	Norfolk	0	0	12	8	0	0	11	12	0	0
Vt:	Burlington	NA	NA	10	7	0	0	36	19	1	2
Wash:	Seattle	2	3	10	7	0	0	15	18	0	0
	Spokane	1	0	9	8	0	0	6	4	0	0
W. Va:	Charleston	0	0	11	8	0	0	13	9	0	0
Wisc:	Milwaukee	NA	NA	8	6	0	0	6	10	0	0
Wyo:	Laramie	0	0	5	4	0	0	6	10	0	0
Network monthly average		0	0	0	8	0	0	13	10	0	0

^a See text for averaging procedure.
^b 12-month averages represent only 9 months data.
 NA, no analysis.

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentra-

tions in milk. These errors were determined by comparing results of a large number of replicate analyses. Table 2 contains averages

for March 1968 and 12-month averages for the period April 1967 through March 1968. The 12-month average enables evaluations of population exposure with respect to the guidance provided by the Federal Radiation Council, which suggests average total daily intakes "averaged over periods of the order of a year," as an appropriate criterion (3). The average radionuclide concentrations are based on results obtained from samples collected weekly. Whenever weekly concentrations were less than or equal to the appropriate minimum detectable levels, zero was used for averaging purposes (2). At very low radionuclide concentrations this often results in averages lower than the

minimum detectable concentration for a single sample, but any positive value reflects at least one weekly sample which was above the minimum detectable level. The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium-89, 5; strontium-90, 2; cesium-137, barium-140, and iodine-131, 10.

The average strontium-90 concentrations in pasteurized milk from selected cities are presented in figure 2.

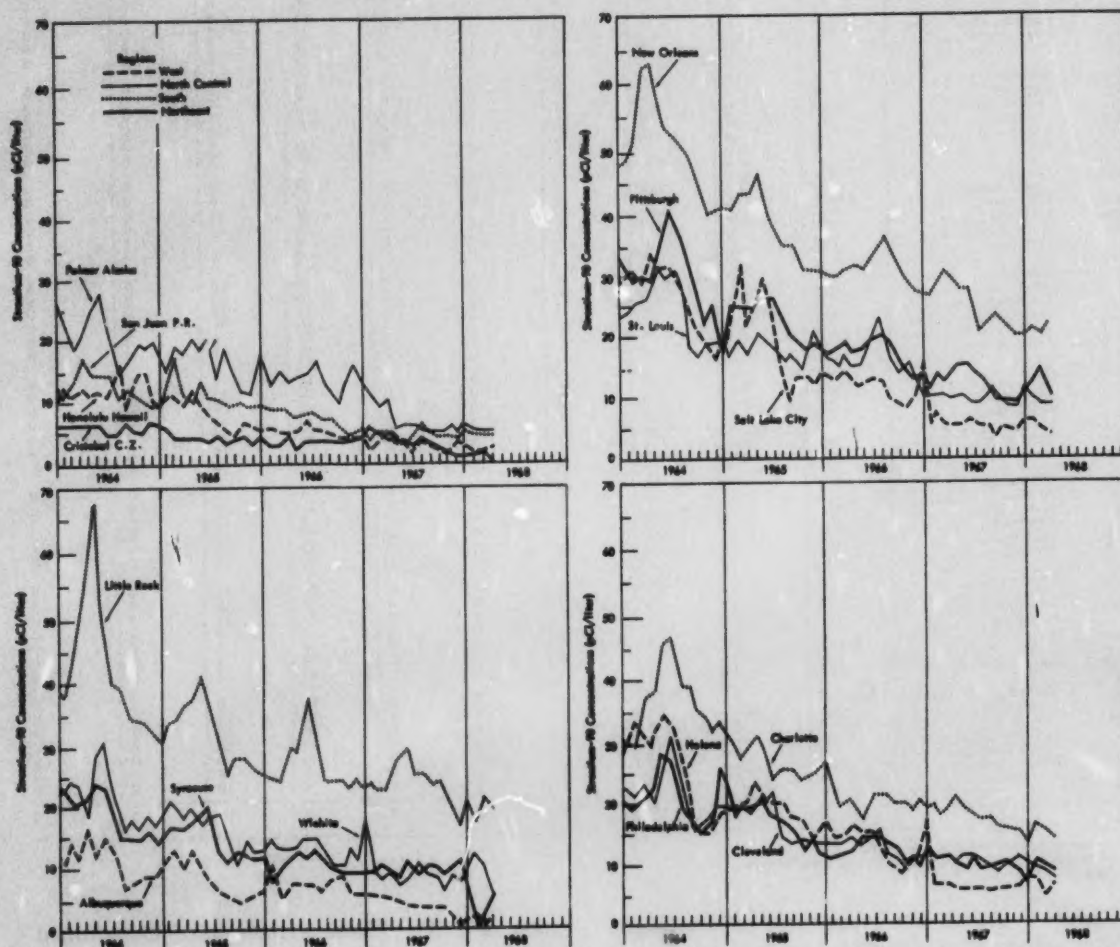


Figure 2. Strontium-90 concentrations in pasteurized milk, 1964-March 1968

2. Canadian Milk Network¹ March 1968

*Radiation Protection Division
Department of National Health and Welfare*

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable

calcium and potassium. The analytical procedures were outlined in the April 1968 issue of *Radiological Health Data and Reports* (4).

The March 1968 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 3. Iodine-131 and strontium-89 concentrations were below minimum detectable levels.

Table 3. Stable elements and radionuclides in Canadian whole milk, March 1968

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium -90 (pCi/ liter)	Cesium -137 (pCi/liter)
Calgary.....	1.11	1.5	9	18
Edmonton.....	1.10	1.5	8	30
Ft. William.....	1.00	1.3	12	19
Fredericton.....	1.04	1.4	14	23
Halifax.....	1.12	1.5	15	19
Montreal.....	1.09	1.5	13	23
Ottawa.....	1.11	1.5	9	23
Quebec.....	1.07	1.5	13	30
Regina.....	1.10	1.5	7	15
St. John's, Nfld.....	1.10	1.5	18	40
Saskatoon.....	1.09	1.4	8	15
Sault Ste. Marie.....	1.02	1.6	14	30
Toronto.....	1.13	1.6	6	13
Vancouver.....	1.11	1.5	14	49
Windsor.....	1.15	1.6	5	17
Winnipeg.....	1.14	1.6	8	30
Average.....	1.10	1.5	11	23

¹ Prepared from April 1968 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.



Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program March 1968

*Pan American Health Organization and
U.S. Public Health Service*

The Pan American Health Organization (PAHO) in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (5).



Figure 4. Pan American Milk Sampling Program stations

Table 4 presents stable potassium, strontium-90 and cesium-137 monthly concentrations for March 1968.

Table 4. Stable element and radionuclide concentration in Pan American milk,* March 1968

Sampling stations	Number of samples	Potassium (g/liter)	Strontium-90 ^b (pCi/liter)	Cesium-137 ^b (pCi/liter)
Chile: Santiago.....	1	1.5	0	0
Colombia: Bogota.....	1	1.5	0	0
Ecuador: Quayaquil.....	1	1.6	0	0
Jamaica: Montego Bay.....	1	1.2	7	195
Canal Zone: Cristobal *	5	1.5	0	5
Puerto Rico: San Juan *	5	1.6	4	14

* All strontium-90 results were ≤ 5 pCi/liter; iodine-131 and barium-140 results were ≤ 10 pCi/liter.

^b Strontium-90 single sample results ≤ 2 pCi/liter and cesium-137 results ≤ 10 pCi/liter are reported as 0.

* For comparison, the radionuclide concentrations in Pasteurized Milk Network samples collected at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

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State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing develop-

mental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows the States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs appearing in this issue are highlighted in the figure. Following is a summary of previously covered State programs, their reporting period, and issue of appearance.

State milk network	Period reported	Last presented
California	October-December 1967	June 1968
Connecticut	October-December 1967	May 1968
Indiana	October-December 1967	May 1968
Iowa	October-December 1967	May 1968
Michigan	October-December 1967	May 1968
Minnesota	October-December 1967	May 1968
New York	October-December 1967	May 1968
Oregon	October-December 1967	June 1968
Pennsylvania	October-December 1967	May 1968
Washington	October-December 1967	June 1968

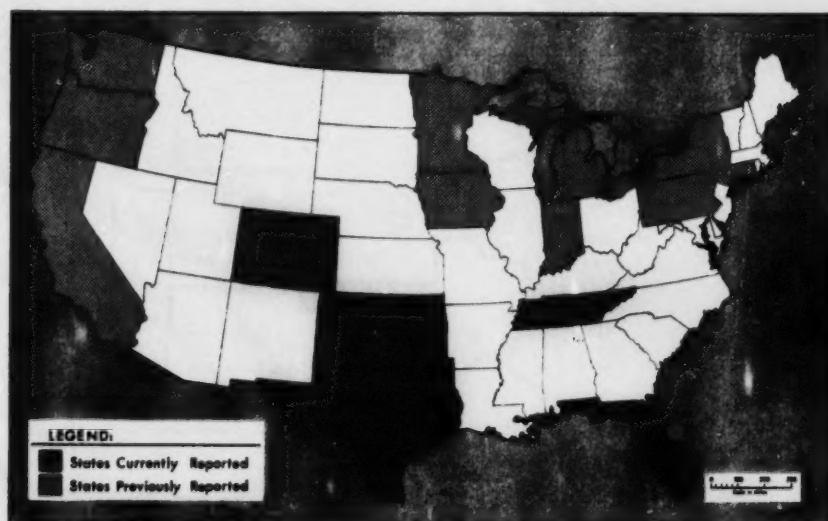


Figure 1. Reported State milk programs

1. Colorado Milk Network January-March 1968

*Air, Occupational and Radiation Hygiene
Division, Colorado State Department
of Public Health*

The Radiation Hygiene Section of the Colorado State Health Department initiated analysis of milk for gamma-ray emitting radionuclides in January 1962. Initially a composite milk sample from the major producers supplying the Denver area was collected by the Denver City and County Health Department for the State.

In August 1962, the State expanded this program to include the sampling of raw milk from the major milk producing areas supplying the entire State. The routine sampling rate was established by the Milk, Food and Drug Section of the State Health Department. Milkshed areas are shown in figure 2.

Analyses are performed for iodine-131, barium-lanthanum-140, cesium-137 and potassium by gamma-ray spectrometry. Employed in this procedure is a 4- by 5-inch diameter NaI (TI) crystal housed in a modified office safe lined with 2 inches of lead and a 512 multi-channel pulse-height analyzer using a type-

writer readout. Samples and backgrounds are counted for 40 minutes in a 2 quart (1,892 ml) Plexiglas Marinelli beaker. Calculation is by the matrix method (1) and minimum detectable concentrations (MDC, 3σ) are: iodine-131, 15 pCi/liter; barium-lanthanum-140, 21 pCi/liter; cesium-137, 16 pCi/liter; and potassium, 0.25 g/liter.

Current summary

Five milk samples were collected and counted during the period from January 1, 1968, to March 31, 1968. (Sampling was curtailed during February and March.) Iodine-131, barium-lanthanum-140 and cesium-137 were below the respective MDC's in all samples. Potassium concentrations averaged 1.46 ± 0.3 (2σ) g/liter.

Recent coverage in Radiological Health Data and Reports:

Period	Issue
July-September 1967	January 1968
October-December 1967	April 1968

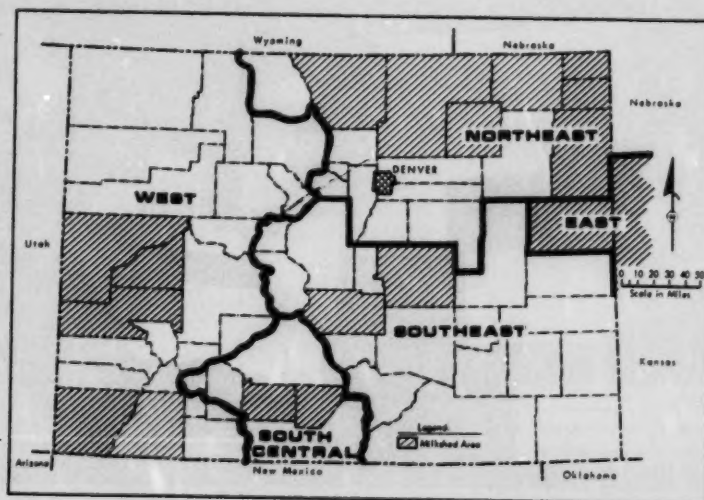


Figure 2. Colorado milk sampling stations

2. Florida Milk Network January-March 1968

*Division of Radiological Health
Florida State Board of Health*

The Florida State Board of Health began sampling raw milk for iodine-131 analysis in two major areas of the State in November 1962. The program has been expanded to include the analysis of milk for strontium-89, strontium-90, cesium-137, barium-140 and potassium, in addition to iodine-131. Monthly samples are taken from randomly selected farms in each of the six regions shown in figure 3. A regional State Board of Health Laboratory is located in each of the six regions. Each laboratory prepares a monthly composite milk sample for its region by combining samples from 10 percent of the dairy farms selected at random. These composite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. In the interest of maintaining an active standby capability, samples are also collected and analyzed for iodine-131 on a monthly basis using the resin cartridge technique (2). Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are characterized by differences in dairying practices related to the gradual transition from small farms in the west Florida region, where locally grown feeds are used, to larger farms in the southern areas, where different types of grass and predominantly purchased feeds are used.

Strontium-89 and strontium-90 are deter-



Figure 3. Florida milk sampling areas

mined by the ion exchange method developed by Porter et al. (3). Iodine-131, cesium-137, barium-140 and potassium are determined by gamma-ray spectrometry (4).

Radionuclide concentration levels for January through March 1968, are presented in table 1. Strontium-89 analyses have been discontinued since 1965 due to extremely low levels. Iodine-131 concentration for this period at all locations were below the minimum detectable level of 20 pCi/liter.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July-September 1967	January 1968
October-December 1967	April 1968

Table 1. Stable element and radionuclide concentrations in Florida raw milk
January-March 1968

Sampling location	Concentration (g/liter)			Radionuclide concentration (pCi/liter)											
	Potassium			Strontium-90			Cesium-137			Barium-140					
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
West.....	1.3	1.2	1.4	NA	26	13	24	25	ND	26	ND	ND	ND	ND	ND
North.....	1.4	1.3	1.4	NA	15	16	ND	ND	ND	ND	ND	ND	ND	ND	ND
Northeast.....	1.3	1.4	1.4	NA	NA	NA	65	66	66	ND	ND	ND	ND	ND	ND
Central.....	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB
Tampa Bay area.....	1.4	1.6	1.4	NA	NA	9	49	62	54	ND	ND	ND	ND	ND	ND
Southeast.....	1.3	1.5	1.6	NA	9	9	58	65	106	ND	ND	ND	ND	ND	21

NA, no analysis.
ND, nondetectable.
NB, no sample.

3. Tennessee Milk Network January-March 1968

*Division of Preventable Diseases
Department of Public Health
State of Tennessee*

The Tennessee Department of Public Health began sampling pasteurized milk for radionuclide analysis in July of 1965. Currently the Department is collecting semimonthly milk samples from three cities (figure 4). In order to obtain a representative sample of the milk consumed in the areas monitored, a sample is collected from each milk distributor supplying the city. The samples from the individual distributors are then composited in proportion to the contribution each makes to the total city milk supply.

Analytical procedures

The semimonthly milk samples from each city are analyzed by gamma-ray scintillation spectrometry for potassium-40, iodine-131, cesium-137, and barium-140, using a 3.5 liter sample (5). After gamma-ray analysis, the samples are stored for 2 weeks to allow in-growth of daughter radioactivity, after which strontium-89, strontium-90, and barium-140 concentrations are determined radiochemically using ion-exchange procedures. Chemical analyses are also made for stable calcium and potassium.

The Chattanooga milk sample is monitored by both the State and the Public Health Serv-

ice's Southeastern Radiological Health Laboratory. This dual examination of aliquot samples provides a crosscheck between the two laboratories.

Results

The monthly average stable element and radionuclide concentrations in Tennessee pasteurized milk are presented in table 2 for the period of January through March 1968. During this period, radionuclide concentrations were below the minimum detectable levels for strontium-89 (<5 pCi/liter), iodine-131 (<9 pCi/liter), and barium-140 (<9 pCi/liter).

Table 2. Radionuclides in Tennessee pasteurized milk January-March 1968

Location	Month 1968	Concentration (g/liter)	Radionuclide concentration (pCi/liter)	
		Potassium	Strontium-90	Cesium-137
Chattanooga	January	1.4	15	19
	February	1.5	14	19
	March	1.6	15	18
Clinton	January	1.3	8	17
	February	1.4	12	20
	March	1.5	10	17
Knoxville	January	1.4	12	14
	February	1.5	15	21
	March	1.6	12	20

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July-September 1967	January 1968
October-December 1967	April 1968

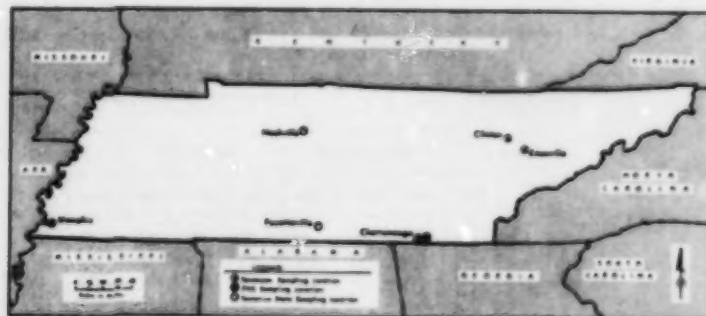


Figure 4. Tennessee pasteurized milk sampling stations

4. Texas Milk Network January-March 1968

Texas State Department of Health²

The Texas State Department of Health initiated a statewide milk sampling network for radionuclide content in April 1964. At present, samples of raw milk are collected from each of twelve sampling points once each calendar quarter. The station locations shown in figure 5 were chosen to give maximum geographical and population coverage.

Samples are routinely analyzed for strontium-90 by a chemical separation technique employing ion exchange columns (6). Prepared samples are counted for 100 minutes in a low-background beta-particle counter.

Potassium-40, iodine-131, barium-140 and cesium-137 concentrations are determined by

gamma-ray spectrometry. The procedure employs a 4- by 4-inch sodium iodide crystal and a 400-channel analyzer. Samples are counted for 100 minutes in a 3.5 liter Marinelli beaker. The matrix method of calculation is used and detection limits at the 95-percent confidence level are 10 pCi/liter.

Results

Potassium-40, strontium-90 and cesium-137 results by station and month for January through March 1968 are presented in table 3. During this time, the iodine-131, and barium-140 concentrations were below their limits of detectability (10 pCi/liter). A summary of radionuclide concentrations in Texas milk for the period from April 1964 through March 1968 is presented in figure 6.

Comparison of the observed radionuclide concentrations with the Federal Radiation Council guides for peacetime operation indicates that at no time during the period of surveillance did the radionuclide concentrations in Texas milk approach levels suggesting any remedial action (7).

² Acknowledgment is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

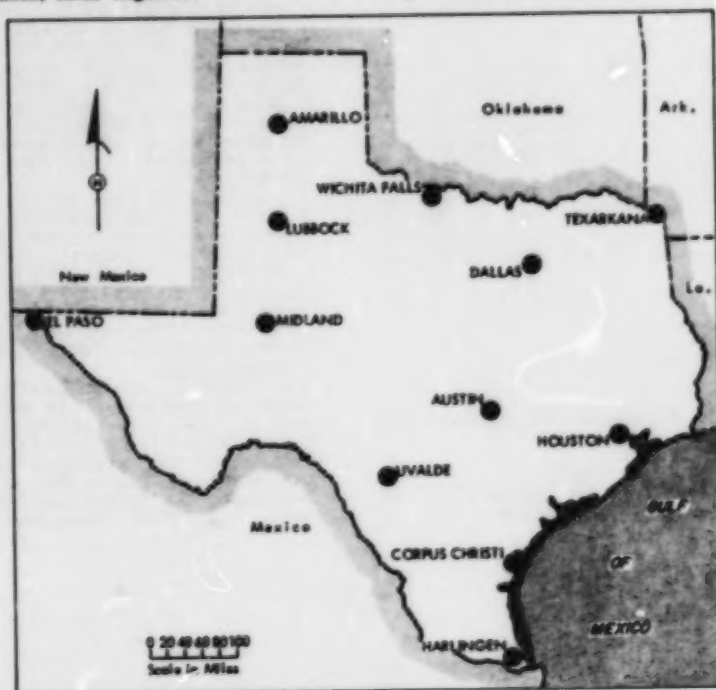


Figure 5. Texas milk sampling stations

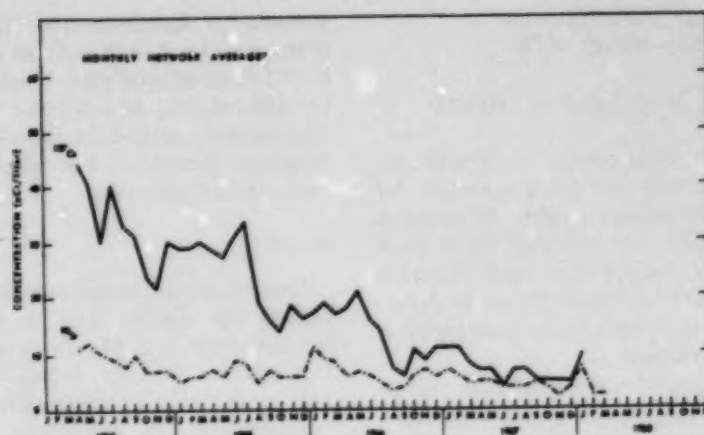


Figure 6. Radionuclide concentrations in Texas milk
April 1964-March 1968

Table 1. Stable element and radionuclide concentrations
in Texas raw milk network, January-March 1968

Sampling location *	Concentration (g/liter)			Radionuclide concentration (pCi/liter)								
	Potassium			Strontium-90			Cesium-137					
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Amarillo.....	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Corpus Christi.....	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
El Paso.....	NS	1.5	NS	NS	2	NS	NS	NS	ND	NS	NS	NS
Fort Worth.....	NS	NS	NS	6	NS	NS	5	NS	NS	NS	NS	NS
Hartings.....	NS	NS	1.0	NS	NS	2	NS	NS	ND	NS	NS	NS
Houston.....	1.5	NS	NS	8	NS	NS	15	NS	NS	NS	NS	NS
Lubbock.....	NS	1.6	NS	NS	3	NS	NS	NS	ND	NS	NS	NS
Midland.....	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
San Antonio.....	NS	NS	1.5	NS	NS	2	NS	NS	NS	NS	NS	NS
Texas.....	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Uvalde.....	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Wichita Falls.....	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

* Samples are collected quarterly from each sampling location on a staggered basis.
ND, nondetectable.
NS, no sample.

Recent coverage in Radiological Health Data and Reports:

Period	Issue
July-September 1967	January 1968
October-December 1967	April 1968

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	July-October 1967	May 1968
Connecticut Standard Diet	July-December 1967	May 1968
Tri-City Diet, HASL	April-December 1967	June 1968
United Kingdom Diet, ARCRL	Annual summary 1965	December 1966

1. Radionuclides in Institutional Diet Samples, October-December 1967 and Annual Summary 1967

*National Center for Radiological Health
and National Center for Urban and
Industrial Health, PHS*

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the National Center for Radiological Health with the assistance of the National Center for Urban and Industrial Health (1).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 basic institutions and 8 auxiliary institutions distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (1,2). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample supplied monthly by each institution represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, and other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period, is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev.; the Southeastern Radiological Health Laboratory, Montgomery, Ala.; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier (3).



Figure 1. Institutional diet sampling locations as of September 1967

Results

Table 1 presents the analytical results for institutional diet samples collected from October through December 1967, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of these samples, reported in pCi/kg of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes, in g/day or pCi/day, were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.78 kg/day compared to the network average of 1.90 kg/day observed from 1961 through 1964 (4).

Strontium-90 dietary intake during this period averaged 14 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (5). Cesium-137 intakes averaged 26 pCi/day during this period. Strontium-89, barium-140, and iodine-131 concentrations were generally below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level will be reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Strontium-89	5 pCi/kg
Strontium-90	2 pCi/kg
Iodine-131	10 pCi/kg
Cesium-137	10 pCi/kg
Barium-140	10 pCi/kg
Radium-226	0.1 pCi/kg

Data from eight auxiliary stations are included for general information and presented in table 2. These stations do not meet the criterion that the majority of the samples are collected from children whose ages range from 9 to 12 years. In order to supplement the existing environmental monitoring networks of the National Center for Radiological Health, these eight institutions are being sampled in the same manner as the basic stations.

Table 1. Concentrations and intake of stable elements and radionuclides in Institutional total diets of children (9-12 years of age), October-December 1967

Location of Institution	Month	Total weight (kg/day)	Calcium		Potassium		⁴⁰ K		¹³⁷ Cs		²²⁶ Ra	
			g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska: Palmer	Oct.	1.70	0.6	1.0	1.3	2.3	10	18	26	48	0.5	0.8
	Nov.	1.83	.5	0.9	1.3	2.3	5	9	17	31	.4	.7
	Dec.	1.85	.5	.9	1.5	2.5	6	10	26	43	.6	1.0
Aris: Phoenix	Oct.	2.07	.6	1.3	1.6	3.2	12	24	0	0	.6	1.2
	Nov.	1.98	.8	1.7	1.4	2.8	11	22	15	30	.7	1.4
	Dec.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Ark: Little Rock	Oct.	1.76	.7	1.3	1.6	2.9	10	17	14	25	.5	.9
	Nov.	1.55	.6	0.9	1.4	2.2	9	14	0	0	.4	.6
	Dec.	1.94	.5	1.0	1.6	3.1	10	19	0	0	.5	1.0
Calif: Los Angeles	Oct.	1.69	.4	.6	1.2	2.0	3	8	0	0	.5	.8
	Nov.	2.02	.4	.8	1.2	2.4	3	7	0	0	.5	1.0
	Dec.	1.48	.4	.6	1.5	2.2	6	9	0	0	.5	.7
Colo: Denver	Oct.	2.43	.7	1.7	1.3	3.2	8	18	19	46	.5	1.2
	Nov.	2.16	.8	1.6	1.6	3.5	3	7	13	26	.6	1.3
	Dec.	2.31	.7	1.7	1.5	3.5	7	17	14	32	.5	1.2
Del: Wilmington	Oct.	2.14	.8	1.6	1.7	3.7	10	21	0	0	.6	1.3
	Nov.	2.39	.6	1.5	1.6	3.6	8	18	12	27	.7	1.6
	Dec.	2.08	.7	1.4	1.6	3.3	7	15	14	29	.7	1.5
Fla: Tampa	Oct.	2.11	.6	1.3	1.6	3.3	6	12	29	61	.5	1.1
	Nov.	2.09	.5	1.1	1.8	3.8	4	9	44	92	.7	1.5
	Dec.	2.15	.6	1.3	1.8	4.0	6	12	54	116	.7	1.5
Hawaii: Honolulu	Oct.	2.16	.5	1.1	1.2	2.7	4	8	12	36	.4	1.2
	Nov.	2.31	NA	NA	1.4	3.3	2	5	18	42	.5	1.3
	Dec.	2.26	.9	3.1	1.4	3.1	4	8	12	27	.4	.9
Idaho: Idaho Falls	Oct.	1.93	1.0	1.9	1.9	3.6	7	13	16	31	.7	1.4
	Nov.	2.12	1.1	2.3	1.8	3.8	7	15	14	30	.5	1.1
	Dec.	2.18	1.2	2.7	1.6	3.5	7	16	13	28	.6	1.3
Ill: Chicago	Oct.	1.30	.7	.9	2.0	2.5	5	6	15	20	.7	.9
	Nov.	1.67	.8	1.4	2.0	3.3	7	12	15	25	.7	1.2
	Dec.	1.46	.7	1.0	1.7	2.5	7	10	24	35	.7	1.0
Ky: Louisville	Oct.	1.39	.7	1.0	1.5	2.5	9	12	12	17	.5	.7
	Nov.	1.82	.7	1.2	1.3	2.4	9	16	0	0	.4	.7
	Dec.	1.44	.8	1.1	1.7	2.4	9	17	0	0	.3	.4
La: New Orleans	Oct.	1.51	.6	.8	1.7	2.5	10	14	18	27	.5	.8
	Nov.	2.00	.8	1.6	1.8	3.6	12	24	19	38	.6	1.2
	Dec.	1.96	.7	1.4	1.6	3.2	12	23	14	27	.4	.8
Mass: Boston	Oct.	1.54	.8	1.2	1.6	2.4	9	14	24	37	.5	.8
	Nov.	1.67	.6	1.1	1.7	2.9	8	13	28	47	.9	1.5
	Dec.	1.50	.8	1.2	1.5	2.4	13	19	17	26	.6	.9
Mo: St. Louis	Oct.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Nov.	2.12	1.0	2.1	1.9	4.0	12	25	16	34	.7	1.5
	Dec.	2.53	1.1	2.8	1.9	4.8	8	21	13	33	.6	1.5
Ohio: Cleveland	Oct.	1.29	.6	.7	2.0	2.6	6	8	11	14	.5	.6
	Nov.	1.30	.6	.7	1.9	2.3	6	7	0	0	.7	.8
	Dec.	1.34	.6	.7	2.0	2.6	6	9	11	15	.8	1.1
Pa: Pittsburgh	Oct.	2.23	.6	1.3	1.4	3.1	6	14	0	0	.5	1.1
	Nov.	2.14	.6	1.3	1.4	3.0	8	16	24	51	.9	1.9
	Dec.	2.25	.6	1.4	1.5	3.4	8	19	18	40	.6	1.4
S. C: Charleston	Oct.	1.48	.7	1.0	1.4	2.0	9	14	26	38	.8	1.3
	Nov.	2.03	.6	1.3	1.5	3.1	11	22	18	37	1.2	2.4
	Dec.	1.49	.6	.9	1.5	2.3	12	18	16	24	1.0	1.5
S. Dak: Sioux Falls	Oct.	1.22	.6	.8	1.9	2.3	7	9	14	17	.7	.8
	Nov.	1.06	.7	.7	1.5	1.5	5	5	15	16	.8	.8
	Dec.	1.21	.6	.8	1.7	2.0	4	4	15	18	.5	.6
Tex: Austin	Oct.	1.70	.5	.9	1.3	2.1	4	7	0	0	.5	.8
	Nov.	1.60	.6	1.0	1.4	2.5	6	10	0	0	.5	.9
	Dec.	1.75	.6	1.0	1.5	2.6	7	13	0	0	.5	.9
Maine: Portland	Oct.	1.40	.8	1.0	1.8	2.5	10	15	30	42	.9	1.3
	Nov.	1.30	.8	1.0	1.6	2.1	10	13	25	32	1.1	1.4
	Dec.	1.44	.9	1.3	1.7	2.4	14	21	26	37	.7	1.0
Wash: Seattle	Oct.	2.27	.5	1.1	1.3	2.9	5	12	20	45	.4	.9
	Nov.	2.12	.5	1.0	1.4	3.0	6	14	12	25	.3	.6
	Dec.	1.79	.9	1.7	1.9	3.4	4	6	22	39	.4	.7
Institutional average	Oct.	1.73	0.6	1.1	1.6	2.6	8	13	14	22	0.6	1.0
	Nov.	1.81	0.7	1.2	1.6	2.8	7	13	16	29	0.7	1.2
	Dec.	1.81	0.7	1.3	1.6	2.9	8	15	15	27	0.6	1.1

* Since food samples were collected from two or more children who were not between the ages of 9-12, data for this month was not used in institutional average.

NA, no analysis.

NS, no sample.

Note: Since iodine-131, barium-140 and strontium-90 were not detectable at most stations during the fourth quarter 1967 no provision was made for these nuclides in the table. The few exceptions are as follows: barium-140 was reported in October for Alaska, and Colorado, 11 pCi/kg. Barium-140 was also reported in December for Washington, 16 pCi/kg. Strontium-90 was reported in November for Colorado, 10 pCi/kg.

Table 2. Concentrations and intake of stable elements and radionuclides in institutional total diets of individuals at auxiliary stations, October-December 1967

Location of Institution	Month	Total weight (kg/day)	Calcium		Potassium		⁸⁶ Br		¹³⁷ Cs		²²⁶ Ra	
			g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska: Juneau	Oct.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Nov.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Dec.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Calif: San Francisco	Oct.	2.05	.6	1.7	1.4	3.7	3	9	11	29	0.9	2.4
	Nov.	2.28	.8	1.8	1.4	3.3	11	24	12	27	.7	1.6
	Dec.	2.60	1.0	2.4	1.5	3.8	4	9	0	0	.6	1.5
Minn: Columbia	Oct.	2.15	1.0	2.1	1.5	3.2	11	23	18	39	.9	1.9
	Nov.	2.03	1.0	2.0	1.5	3.1	14	28	19	39	.9	1.8
	Dec.	2.22	1.0	2.1	1.4	3.1	12	28	0	0	.6	1.3
Nebr: Omaha	Oct.	2.13	1.0	2.2	1.8	3.8	7	16	0	0	.5	1.1
	Nov.	2.28	.8	1.9	1.8	4.1	6	14	18	36	.4	.9
	Dec.	2.08	.9	1.9	1.9	3.9	5	10	0	0	1.3	2.7
Nev: Carson City	Oct.	1.25	.6	.7	1.7	2.1	6	8	17	21	.7	.9
	Nov.	1.51	.6	1.0	1.6	2.5	3	4	15	23	.6	.9
	Dec.	1.76	.8	1.5	1.7	3.0	6	11	0	0	.6	1.1
N. Mex: Albuquerque	Oct.	2.22	.9	1.9	1.8	3.9	4	9	0	0	.3	.7
	Nov.	2.56	.8	2.1	1.5	3.9	4	11	18	46	.5	1.3
	Dec.	1.44	.6	.9	1.6	2.8	4	6	15	22	.4	.6
Ore: Woodburn	Oct.	2.48	.5	1.3	1.5	4.1	6	15	19	47	.5	1.2
	Nov.	2.87	.8	1.5	1.8	4.7	5	13	31	80	.4	1.0
	Dec.	2.35	.7	1.6	1.5	3.5	3	7	12	28	.6	1.4
Utah: American Fork	Oct.	2.22	.4	.9	.8	1.8	6	12	12	27	.5	1.1
	Nov.	1.80	.7	1.3	1.4	2.6	6	10	0	0	.6	1.1
	Dec.	1.94	.5	1.0	1.4	2.6	5	9	0	0	.3	.6
Institutional average	Oct.	2.16	0.7	1.5	1.5	3.2	6	13	11	23	0.6	1.3
	Nov.	2.13	0.8	1.7	1.6	3.5	7	15	16	36	0.6	1.2
	Dec.	2.04	0.8	1.6	1.6	3.2	6	11	4	7	0.6	1.3

NA, no analysis.

NS, no sample.

Note: Since iodine-131, barium-140, and strontium-90 were not detectable at most stations during the fourth quarter 1967, no provision was made for these nuclides in the table. The few exceptions are as follows: barium-140 was reported in October for California, 14 pCi/kg; and Nevada, 11 pCi/kg. Barium-140 was also reported in December for New Mexico, 13 pCi/kg. Strontium-90 was reported in November for Oregon, 6 pCi/kg.

Table 3. 1967 annual average concentration and intake of stable elements and radionuclides in institutional total diets of children (9-12 years of age)

Location of Institution	Total weight (kg/day)	Calcium		Potassium		⁸⁶ Br		¹³⁷ Cs		²²⁶ Ra	
		g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska: Palmer	1.60	0.5	0.8	1.4	2.2	8	13	27	42	0.6	1.0
Ark: Phoenix	1.92	.7	1.3	1.5	2.8	6	12	7	13	.7	1.3
Ark: Little Rock	1.49	.6	.9	1.6	2.4	13	19	14	21	.8	1.1
Calif: Los Angeles	1.96	.7	1.4	1.5	2.9	4	9	6	13	.5	1.1
Colo: Denver	2.25	.7	1.5	1.5	3.4	7	15	14	32	.6	1.4
Del: Wilmington	2.20	.7	1.6	1.8	3.9	9	20	14	32	.7	1.5
Fla: Tampa	2.09	.6	1.2	1.8	3.7	7	14	41	86	1.0	2.1
Hawaii: Honolulu	2.27	.4	1.0	1.4	3.2	3	6	15	35	.5	1.2
Idaho: Idaho Falls	1.95	1.1	2.1	1.8	3.6	8	16	16	32	.7	1.3
Ill: Chicago	1.62	.7	1.2	1.7	2.8	7	12	17	27	.7	1.1
Ky: Louisville	1.50	.8	1.2	1.7	2.6	10	18	10	16	1.6	2.4
La: New Orleans	1.82	.7	1.2	1.7	3.1	13	23	21	40	.7	1.3
Maine: Portland	1.30	.8	1.0	1.8	2.2	12	15	25	33	.8	1.0
Mass: Boston	1.66	.7	1.3	1.6	2.7	11	18	26	44	.6	1.0
Mo: St. Louis	1.74	.9	1.6	1.8	3.1	12	20	14	24	.7	1.2
Ohio: Cleveland	1.34	.6	.8	2.0	2.6	7	10	11	15	.8	1.0
Pa: Pittsburgh	2.21	.6	1.3	1.5	3.1	7	13	14	31	.6	1.4
S. C: Charleston	1.61	.6	1.0	1.4	2.8	11	17	26	42	1.4	2.2
S. Dak: Sioux Falls	1.19	.7	.8	1.7	2.0	6	7	11	13	.7	0.8
Tex: Austin	1.71	.6	1.0	1.3	2.3	6	9	4	7	.8	1.4
Wash: Seattle	1.90	.7	1.3	1.5	2.8	7	13	30	40	.5	1.0
Institutional average	1.77	0.7	1.2	1.6	2.8	8	14	17	30	0.8	1.3

* This data was not included in the institutional average since all children were not between 9-12 years of age.

* Institution change in August 1967, from Burlington, Vt. to Portland, Maine.

Note: Since iodine-131, barium-140, and strontium-90 were not detectable at most stations during the year 1967, no provision was made for these nuclides in the table. The exceptions for January 1967 are: 30 pCi/kg of iodine-131 reported for Louisiana and Arizona. Barium-140 was reported for the following institutions: Alaska, 20 pCi/kg; Utah, 17 pCi/kg; and Washington, 30 pCi/kg.

May 1967: 13 pCi/kg of iodine-131 was reported for Arizona.

September 1967: 18 pCi/kg of barium-140 was reported in Arizona.

October 1967: 11 pCi/kg of barium-140 was reported for Alaska and Colorado.

November 1967: 10 pCi/kg of strontium-90 was reported in Colorado.

December 1967: 11 pCi/kg of barium-140 was reported in Colorado and 16 pCi/kg in Washington.

Table 4. 1967 annual average concentrations and intake of stable elements and radionuclides in Institutional total diets of individuals (auxiliary stations)

Location of Institution	Total weight (kg/day)	Calcium		Potassium		¹³⁷ Cs		¹³⁴ Cs		²²⁶ Ra	
		g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska: Juneau.....	2.55	0.3	0.8	1.0	3.6	4	10	8	19	0.4	1.0
Calif: San Francisco.....	2.42	.7	1.7	1.5	3.5	5	12	10	26	.8	1.9
Miss: Columbia.....	2.16	.9	2.0	1.5	3.2	11	24	18	38	1.3	2.8
Nebr: Omaha.....	2.14	.9	1.9	1.8	3.9	7	15	11	24	.9	1.8
Nev: Carson City.....	1.44	.7	1.0	1.7	2.4	5	7	13	18	.7	1.1
N. Mex: Albuquerque.....	2.32	.8	1.9	1.7	3.9	4	10	6	14	.6	1.3
Oregon: Woodburn.....	2.46	.6	1.4	1.7	4.1	5	14	19	48	.5	1.3
Utah: American Fork.....	1.93	.6	1.1	1.2	2.3	5	8	6	11	.5	0.9
Institutional average.....	2.18	0.7	1.5	1.5	3.2	6	12	11	25	0.7	1.5

Note: Since iodine-131, barium-140, and strontium-89 were not detectable at most stations during the year 1967 no provision was made for these nuclides in the table. The exceptions are as follows:
 January 1967: 27 pCi/kg of iodine-131 was reported in Mississippi and 29 pCi/kg in Nevada. 17 pCi/kg of barium-140 was reported in Utah, 31 pCi/kg in Nevada.
 March 1967: Barium-140 was reported for Oregon, 13 pCi/kg.
 May 1967: 11 pCi/kg of iodine-131 was reported in Oregon and Utah.
 October 1967: Barium-140 was reported in California, 14 pCi/kg in Nevada.
 November 1967: 6 pCi/kg of strontium-89 was reported in Nevada.
 December 1967: 13 pCi/kg of barium-140 was reported in New Mexico.

Annual averages

Annual average radionuclide concentrations and intakes are presented in tables 3 and 4 for the basic and auxiliary stations. During 1967, the annual average intake for the basic stations was 1.77 kg/day as compared to 2.18 kg/day in the auxiliary stations. This is due to the fact that the basic stations sample diets of children from ages 9-12 while the auxiliary stations usually sample diets of children who are older and consume more food. The levels of radionuclide intake in both the basic and auxiliary stations were similar.

Recent coverage in Radiological Health Data and Reports:

Period	Issue
April-June 1967	January 1968
July-September 1967	April 1968

REFERENCES

- (1) ANDERSON, E. C., and D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391-1400 (September 1962).
- (2) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January-March 1965. Radiol Health Data 6:548-554 (October 1965).
- (3) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, April-June 1965. Radiol Health Data 7:92-98 (February 1966).
- (4) GRUNDY, R. D., C. CALVERT, and A. G. BERGER. Summary of results of Institutional Total Diet Sampling Network, 1961-1964. Radiol Health Data 6:691-698 (December 1965).
- (5) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (1). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (2-4), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively.

Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence¹ of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

¹ Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water Sampling Program	Period reported	Last presented
California	January-June 1967	June 1968
Colorado River Basin	1965-1966	May 1968
Coast Guard	January-December 1966	November 1967
Minnesota	January-June 1967	January 1968
New York	January-May 1967	January 1968
Radiostromium in Tap Water, HASL	July-December 1967	June 1968
Washington	July 1965-June 1966	August 1967

REFERENCES

- (1) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).
- (2) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

- (3) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402 (May 1960).
- (4) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, January 1968

Division of Pollution Surveillance
Federal Water Pollution Control
Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in sus-

pended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (1-6). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity concentration is 15 pCi/liter or greater or when the beta radioactivity concentration is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service

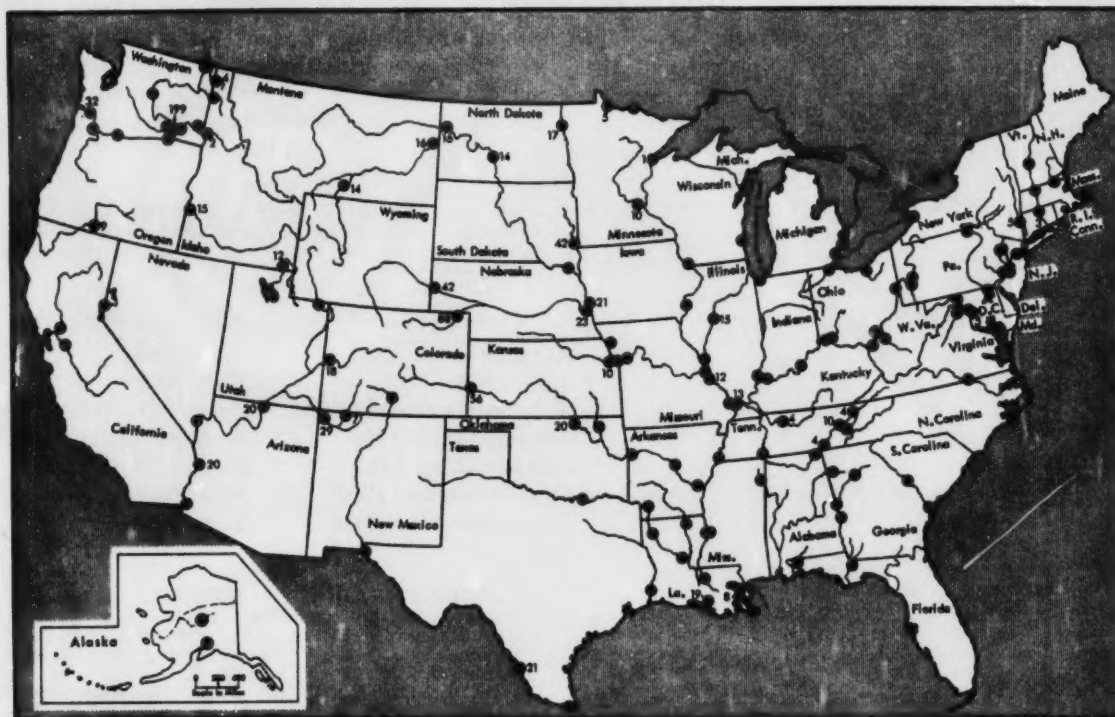


Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, January 1968

Table 1. Radioactivity in raw surface waters, January 1968

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)			Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:							E. St. Louis, Ill.	1	0	1	7	5	12
Cedar Hill, N. Mex.	1	1	2	3	5	7	New Orleans, La.	3	0	3	6	2	8
Arkansas River:							Missouri River:						
Coolidge, Kans.	<1	46	46	5	51	56	Williston, N. Dak.	0	4	4	3	13	16
Forten City, Okla.	0	6	6	1	19	20	Blamark, N. Dak.	0	3	3	1	13	14
Atchafalaya River:							St. Joseph, Mo.	0	5	5	3	19	21
Morgan City, La.	3	0	3	12	7	19	North Platte River:						
Bear River:							Henry, Nebr.	1	26	27	5	37	42
Preston, Idaho.	0	3	3	0	12	12	Ohio River:						
Big Horn River:							Cairo, Ill.	2	0	2	8	5	12
Hardin, Mont.	0	3	3	1	13	14	Peard Orville River:						
Big Sioux River:							Albion Falls Dam,						
Sioux Falls, S. Dak.	0	3	3	1	41	42	Idaho.	0	<1	<1	<1	4	4
Clearwater River:							Platte River:						
Lewiston, Idaho.	0	0	0	<1	2	2	Plattsmouth, Nebr.	1	5	6	3	31	28
Clinch River:							Potomac River:						
Clinton, Tenn.	0	0	0	0	4	4	Washington, D. C.	0	0	0	1	4	5
Kingston, Tenn.	0	0	0	1	9	10	Rainy River:						
Colorado River:							Baudette, Minn.	0	0	0	4	1	5
Loma, Colo.	2	4	6	7	11	18	Red River, North:						
Page, Ariz.	0	6	6	<1	30	20	Grand Forks:						
Parker Dam, Calif.							N. Dak.	0	1	1	1	16	17
Aris.	0	7	7	0	20	20	Rio Grande:						
Columbia River:							Laredo, Tex.	1	6	7	8	13	21
Pasco, Wash.	0	1	1	28	171	199	San Juan River:						
Clatskanie, Ore.	0	<1	<1	5	27	32	Shiprock, N. Mex.	7	2	9	21	8	29
Connecticut River:							Savannah River:						
Enfield Dam, Conn.	0	0	0	0	3	3	Port Wentworth,						
Cumberland River:							Ga.	<1	0	<1	2	7	9
Chatham Lock,							Snake River:						
Tenn.	0	0	0	0	4	4	Payette, Idaho.	0	6	6	<1	15	15
Great Lakes:							South Platte River:						
Duluth, Minn.	0	0	0	0	1	1	Julesburg, Colo.	8	46	54	21	67	88
Hudson River:							Tennessee River:						
Poughkeepsie, N. Y.	0	0	0	1	4	5	Chattanooga, Tenn.	0	0	0	1	3	4
Illinois River:							Yellowstone River:						
Peoria, Ill.	0	2	2	3	12	15	Sidney, Mont.	0	3	3	0	16	16
Kansas River:							Maximum.	8	46	54	28	171	199
DeSoto, Kans.	0	3	3	2	8	10	Minimum.	0	0	0	0	1	1
Klamath River:													
Keno, Ore.	0	0	0	1	8	9							
Mississippi River:													
St. Paul, Minn.	0	0	0	1	9	10							

* Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (7). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During January, the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for dissolved solids:

Arkansas River; Coolidge, Kans.
North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

During January 1968, Pasco, Wash., on the Columbia River increased in average value to more than 150 pCi/liter on beta radioactivity for dissolved solids.

REFERENCES

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- (2) *Ibid.*, 1959 Edition.
- (3) *Ibid.*, 1960 Edition.
- (4) *Ibid.*, 1961 Edition.
- (5) *Ibid.*, 1962 Edition.
- (6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
- (7) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961-1965. Radiol Health Data Rep 9:1-12 (January 1968).

Radioactivity in Florida Waters, 1965 and 1966¹

*Division of Radiological Health
Florida State Board of Health*

The Florida State Board of Health samples raw surface water from locations in 13 hydrological subbasins. In nine of these subbasins, raw ground water is also sampled. The samples are collected on a variable frequency and analyzed for gross alpha and beta radioactivity.

Figure 1 shows the locations of the surface water subbasins from which samples are obtained. Average gross alpha and gross beta radioactivity levels in raw surface waters during 1965 are presented in table 1; table 2 gives the radioactivity levels in ground waters.

In addition to the sampling done by the Florida State Board of Health, the Bioenvironmen-

tal Engineering Research Laboratory, University of Florida, samples raw surface water and water supplies in Alachua County and analyzes the samples for gross alpha and gross beta radioactivity. Samples are taken monthly from each sampling point with the exception of the City of Gainesville where raw water is sampled daily. These data for 1965 are summarized in table 3 as quarterly and yearly averages.

The yearly average beta radioactivity in surface waters was slightly higher than that in ground waters. This additional beta radioactivity in surface waters can be attributed to fallout. The alpha radioactivity, which is attributed to natural radioactivity of minerals, is the same for ground and surface water.

During 1966, 64 samples out of a total of 421 collected from the 238 sampling sites showed gross beta radioactivity greater than the minimum reporting concentration of 10

¹ Data taken from "Report of Florida Radiological Data, Environmental Monitoring Programs, 1965" and "Report of Florida Radiological Data, Environmental Monitoring Programs, 1966," Florida State Board of Health, Bureau of Preventable Diseases, Division of Radiological Health, Jacksonville, Fla.



Figure 1. Hydrological surface subbasins in Florida

Table 1. Gross alpha and beta radioactivity in raw surface water, 1965

Location subbasin	Radioactivity concentration (pCi/liter)									
	January-March		April-June		July-September		October-December		Yearly average	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
St. Marys-Nassau River.....			* (4) 0.7	(4) 66.0					(4) 0.7	(4) 66.0
St. Johns River.....	(25) 0.5	(25) 13.5	(10) 0.6	(19) 42.2	(22) 0.1	(22) 24.7	(27) 0.1	(27) 16.6	(103) 0.3	(103) 22.2
Suwannee River.....	(7) 0.2	(7) 10.4					(8) 0.1	(8) 7.6	(12) 0.3	(12) 14.0
Ochlocknee-St. Marys River.....	(5) 0.7	(3) 9.7			(8) ND	(8) 6.6	(2) ND	(2) 4.0	(13) 0.2	(13) 7.0
Withlacoochee River.....									NS	NS
Tampa Bay Area.....	(4) 0.5	(4) 17.2	(3) 0.3	(3) 32.3			(5) ND	(5) 10.3	(12) 0.2	(12) 18.3
Peace River.....	(1) 0.8	(1) 19.0			(4) 0.1	(4) 9.0			(5) 0.2	(5) 10.2
Kissimmee River.....	(1) 0.2	(1) 20.0	(1) 0.3	(1) 40.0	(4) 0.5	(4) 19.7	(5) ND	(5) 18.6	(11) 0.2	(11) 22.7
Florida East Coastal area.....	(20) 0.3	(20) 27.7	(30) 0.5	(30) 55.1	(26) ND	(26) 29.3	(21) ND	(21) 22.6	(116) 0.2	(116) 34.4
Lower Florida area.....	(7) 0.2	(7) 7.2	(12) 0.3	(12) 20.7	(8) ND	(8) 6.0	(12) ND	(12) 6.7	(29) 0.1	(29) 11.0
Apalachicola River.....	(1) 0.4	(1) 10.0					(3) ND	(3) 120	(4) 0.1	(4) 92.5
Choctawhatchee River.....	(3) 0.3	(3) 6.0					(6) ND	(6) 5.3	(9) 0.1	(9) 5.5
Perdido-Escambia Rivers.....	(4) 0.3	(4) 11.0					(4) 0.5	(4) 5.5	(8) 0.4	(8) 8.2
Average.....	(85) 0.4	(85) 19.2	(69) 0.5	(69) 45.2	(92) 0.1	(92) 22.4	(91) 0.1	(91) 17.9		

* Number in parentheses indicates number of samples.
 ND, nondetectable.
 NS, no sample reported.

Table 2. Gross alpha and beta radioactivity in ground water, 1965

Location subbasin	Radioactivity concentration (pCi/liter)									
	January-March		April-June		July-September		October-December		Yearly average	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
St. Marys-Nassau River.....			* (1) ND	(1) 4.0					(1) ND	(1) 4.0
St. Johns River.....					(2) ND	(2) ND	(2) 0.3	(2) ND	(4) 0.1	(4) ND
Suwannee River.....	(1) 0.8	(1) 10.0					(1) ND	(1) ND	(2) 0.4	(2) 5.0
Ochlocknee-St. Marys River.....					(1) ND	(1) ND	(1) ND	(1) ND	(2) ND	(2) ND
Withlacoochee River.....									NS	NS
Tampa Bay area.....	(2) 0.3	(2) 45.0							(2) 0.3	(2) 45.0
Peace River.....									NS	NS
Kissimmee River.....					(1) ND	(1) ND			(1) ND	(1) ND
Florida East Coastal area.....									NS	NS
Lower Florida area.....			(2) 5.3	(2) 127.0			(2) 1.0	(2) 66.0	(4) 3.1	(4) 97.5
Apalachicola River.....									NS	NS
Choctawhatchee River.....	(7) 0.3	(7) 5.4					(4) ND	(4) 3.3	(11) 0.2	(11) 4.5
Perdido-Escambia Rivers.....							(1) ND	(1) 6.0	(1) ND	(1) 6.0
Average.....	(10) 0.4	(10) 13.8	(3) 3.5	(3) 86.0	(4) ND	(4) ND	(11) 0.2	(11) 12.9		

* Number in parentheses indicates number of samples.
 ND, nondetectable.
 NS, no sample reported.

Table 2. Gross alpha and beta radioactivity in raw water, 1965

Location	Radioactivity concentration (pCi/liter)									
	January-March		April-June		July-September		October-December		Yearly average	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
Alachua County: 19 sampling locations.....	0.8	8.5	0.8	8.2	0.1	8.3	0.4	8.1	0.5	8.3
City of Gainesville.....	0.1	5.0	0.1	4.3	0.1	4.3	0.1	4.8	0.1	4.8

pCi/liter. Those 64 samples averaged 36 pCi/liter of gross beta radioactivity. Only 5 of the 421 samples, which averaged 10 pCi/liter of gross alpha radioactivity, were greater than the minimum reporting concentration of 7 pCi/liter. The average gross beta radioactivity in water supplies is well below the limitations imposed by the standard for gross beta radioactivity in drinking water (1,000 pCi/liter) (1).

The Bioenvironmental Engineering Research Laboratory reported that only 32 of the municipal water samples (City of Gainesville) and 50

of the surface water samples (Alachua County), were greater than the reporting minimum in 1966. The 32 municipal water supply samples averaged 16 pCi/liter of gross beta radioactivity and the 50 surface water samples averaged 19 pCi/liter of gross beta radioactivity.

REFERENCE

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the

Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*:

Network	Period	Issue
HASL Fallout Network	January-June 1967	March 1968
HASL 80th Meridian Network	Calendar Year 1965	January 1967
Plutonium in Airborne Particulates	April-June 1967	November 1967

I. Radiation Alert Network March 1968

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection when most of the radon daughter products have decayed and at 29 hours after collection when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate National Center for Radiological Health offi-

cials by mail or telephone, depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (1). A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique during March 1968. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting stations.



Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, March 1968

Station location	Number of samples		Air surveillance gross beta radioactivity ($\mu\text{Ci}/\text{m}^3$)			Last profile in RHD&R	Precipitation			
							Total depth (mm)	Field estimation of deposition		
	Air	Pptn	Maximum	Minimum	Average *			Number of samples	Depth (mm)	Total deposition ($\mu\text{Ci}/\text{m}^2$)
Ala: Montgomery	31	3	7.08	0.30	2.81	Nov 67	75	2	84	8
Alaska: Adak	(*)					Apr 68	(*)			
Anchorage	20	1	.38	.00	.01	Dec 67	1	1	1	0
Attu Island	(*)					May 68	(*)			
Fairbanks	(*)					Jan 68	(*)			
Juneau	20	13	.00	.00	.00	Feb 68	184	13	184	0
Kodiak	21		.44	.00	.20	Mar 68	(*)			
Nome	(*)					July 68	(*)			
Pt. Barrow	31		1.30	1.03	1.09	June 68	(*)			
St. Paul Island	30		.98	.43	.45	Oct 67	(*)			
Phoenix	21		11.57	.93	2.18	Feb 68	(*)			
Ark: Little Rock	13	3	2.85	.49	1.08	Dec 67	86	0	0	(*)
Calif: Berkeley	20	6	.73	.00	.34	Mar 68	90	6	90	0
Los Angeles	31	4	2.08	.28	1.00	July 68	63	4	63	0
Con: Ancon	17		3.12	1.30	2.10	Mar 68	(*)			
Colo: Denver	21	2	4.26	.79	1.83	Mar 68	13	(*)	(*)	(*)
Conn: Hartford	19	8	.51	.31	.28	Jan 68	111	8	111	38
Del: Dover	21		1.05	.00	.40	Nov 67	(*)			
D. C.: Washington	29	6	2.16	.00	.93	June 68	101	6	101	80
Fla: Jacksonville	20	4	2.43	.33	.80	Dec 67	34	4	34	0
Miami	18	4	.75	.34	.50	Jan 68	14	4	14	0
Ga: Atlanta	21	4	1.62	.80	1.12	Oct 67	113	0	0	(*)
Guam: Agaña	21		.88	.00	.32	Nov 67	(*)			
Hawaii: Honolulu	30	3	1.20	.30	.57	May 68	35	(*)	(*)	(*)
Idaho: Boise	21	6	4.00	.85	1.88	May 68	25	6	25	2
Ill: Springfield	21	3	3.13	.35	.97	June 68	41	0	0	(*)
Ind: Indianapolis	20	6	2.18	.77	1.32	Oct 67	33	6	33	82
Iowa: Iowa City	21	2	2.42	.65	1.20	Mar 68	21	1	7	0
Kans: Topeka	21	3	3.74	.56	1.51	Dec 67	3	3	3	0
Ky: Frankfort	10	5	.68	.30	.43	June 68	37	5	37	64
La: New Orleans	20	4	1.00	.22	.53	June 68	45	(*)	(*)	(*)
Maine: Augusta	21	8	1.04	.60	.40	July 68	118	8	118	0
Md: Baltimore	20	4	4.88	.00	.85	Jan 68	35	4	35	11
Rockville	(*)					May 68	86	(*)	(*)	(*)
Mass: Lawrence	21	9	1.78	.00	.33	Nov 67	174	0	0	(*)
Winchester	21	7	2.49	.00	.21	Apr 68	108	7	108	0
Mich: Lansing	16		2.31	.50	1.03	May 68	(*)			
Minn: Minneapolis	21	7	.66	.10	.23	Nov 67	54	7	54	41
Miss: Jackson	18	4	1.00	.00	.34	July 68	91	4	91	52
Mo: Jefferson City	21	6	1.42	.34	.71	Oct 67	29	6	29	2
Mont: Helena	20	2	2.80	.23	1.05	Apr 68	12	2	12	16
Neb: Lincoln	19		4.01	1.11	1.97	Oct 67	(*)			
Nev: Las Vegas	16		3.42	1.14	2.18	Jan 68	(*)			
N. H.: Concord	18		1.09	.49	.65	June 68	(*)			
N. J.: Trenton	19	4	.83	.10	.33	July 68	135	4	135	0
N. Mex: Santa Fe	17	3	1.26	.33	.66	Apr 68	15	3	15	0
N. Y.: Albany	21	6	.94	.52	.34	Oct 67	50	6	50	48
Buffalo	21		.95	.29	.50	Mar 68	(*)			
New York City	21		.50	.30	.37	Apr 68	(*)			
N. C.: Gastonia	17	2	13.71	.53	3.71	Mar 68	50	(*)	(*)	(*)
N. Dak: Bismarck	17	2	3.36	.00	.79	June 68	18	0	0	(*)
Ohio: Cincinnati	18		2.46	.73	1.25	Nov 67	(*)			
Columbus	19	6	1.89	.33	.72	July 68	50	5	56	0
Painesville	21	6	.95	.21	.30	Jan 68	32	6	32	5
Okl: Oklahoma City	14	4	1.45	.00	.60	May 68	27	3	16	0
Fonca City	21	5	1.16	.23	.58	Jan 68	48	5	48	0
Ore: Portland	19	14	.97	.00	.32	Oct 67	72	14	72	0
Pa: Harrisburg	17		2.26	.26	.94	Oct 67	(*)			
P. R.: San Juan	(*)					July 68	(*)			
R. I.: Providence	19	6	.76	.09	.29	May 68	175	0	0	(*)
S. C.: Columbia	8	4	.79	.17	.41	Apr 68	84	0	0	(*)
S. Dak: Pierre	17		7.90	.97	2.45	Feb 68	(*)			
Tenn: Nashville	16	7	1.84	.80	.89	May 68	111	7	111	0
Tex: Austin	21	4	6.08	.62	2.63	Nov 67	61	(*)	(*)	(*)
El Paso	20	4	6.93	.65	2.82	June 68	17	4	17	0
Utah: Salt Lake City	30	8	2.10	.28	.83	July 68	76	1	10	0
Vt: Barre	20	8	1.41	.23	.48	Dec 67	78	8	78	0
Richmond	17	6	.90	.20	.54	Dec 67	85	0	0	(*)
Wash: Seattle	(*)	14				Dec 67	105	(*)	(*)	(*)
Spokane	21	1	2.52	.93	1.41	Nov 67	1	0	0	(*)
W. Va: Charleston	20	9	2.46	.22	.82	Apr 68	98	9	98	62
Wis: Madison	21	2	.93	.25	.48	Dec 67	14	2	14	14
Wyo: Cheyenne	21	1	5.53	.67	2.08	Jan 68	9	1	9	10
Network summary	1,324	263	13.71	0.00	1.00		62	5	54	14

* The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.

* No report received. (Air samples received without field estimate data are not considered by the data program).

* No precipitation samples collected.

* Indicates that the station is part of the plutonium in precipitation network. No gross beta measurements are done.

* Samples were collected but no field estimates were reported.

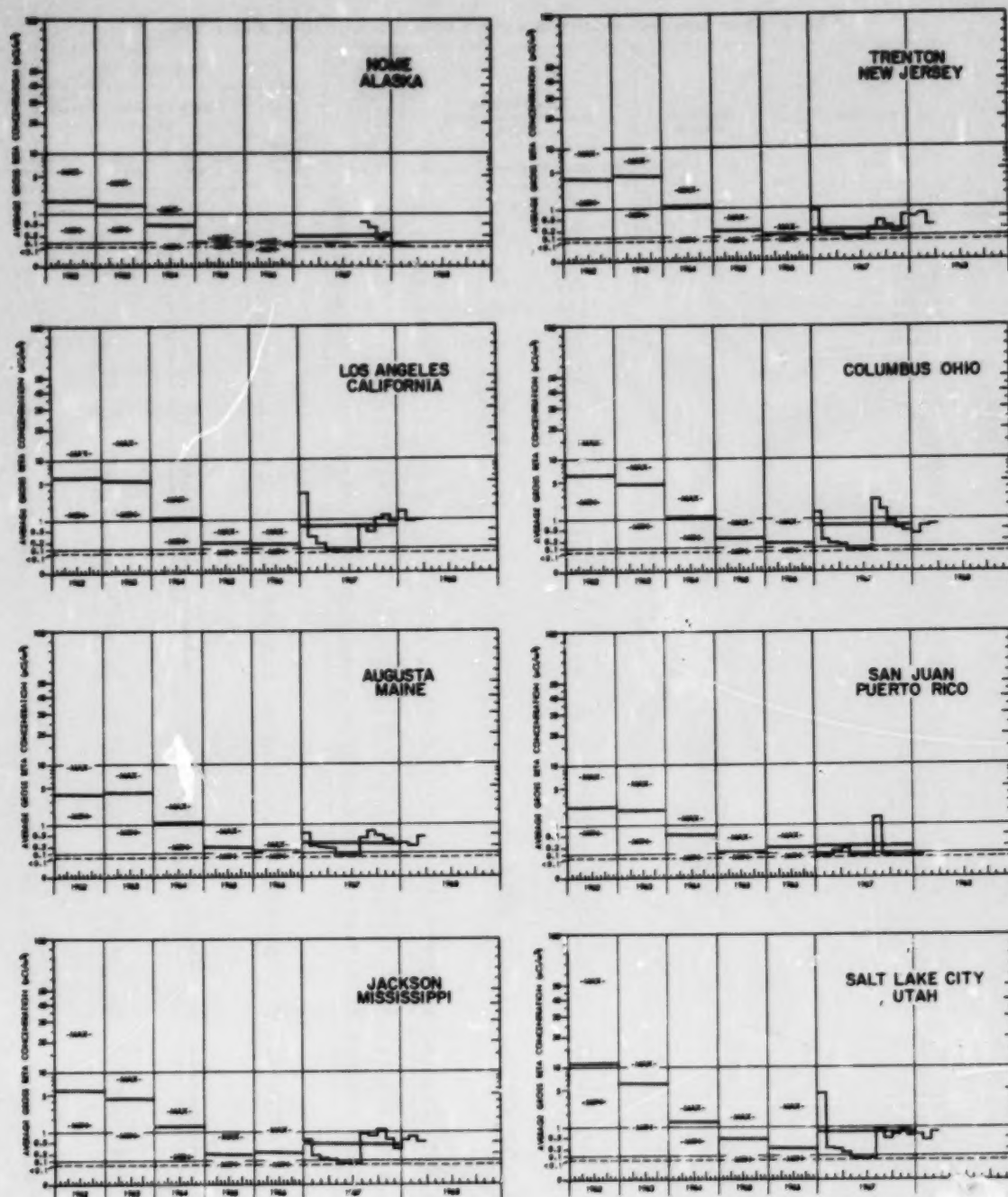


Figure 2. Monthly and yearly profiles of beta radioactivity in air—
Radiation Surveillance Network, 1962-March 1968

2. Canadian Air and Precipitation Monitoring Program,¹ March 1968

Radiation Protection Division

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (2-6).

A summary of the sampling procedures and methods of analysis was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for March 1968 are presented in table 2.

¹ Prepared from information and data in the April 1968 Monthly report "Data from Radiation Protection Program" Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, March 1968

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m ³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m ²)
Calgary	31	0.5	0.1	0.2	43	0.8
Coral Harbour	31	.2	.1	.1	23	1.2
Edmonton	31	.4	.1	.1	68	1.3
Ft. Churchill	31	.2	.0	.1	13	.5
Ft. William	31	.3	.1	.2	101	7.4
Fredericton	31	.4	.0	.2	50	5.3
Goose Bay	31	.2	.1	.1	17	1.6
Halifax	30	.3	.0	.2	9	1.3
Inuvik	31	.2	.1	.2	29	.3
Montreal	31	.4	.1	.2	61	5.1
Moosonee	31	.6	.1	.3	36	1.4
Ottawa	30	.3	.0	.2	85	7.0
Quebec	31	.3	.0	.2	77	5.8
Regina	31	.5	.0	.2	177	1.2
Resolute	27	.4	.0	.2	NS	NS
St. John's, Nfld.	31	.2	.0	.1	22	3.5
Saskatoon	31	.2	.0	.1	54	1.3
Sault Ste Marie	26	.6	.1	.3	134	7.8
Toronto	31	.6	.0	.2	37	1.8
Vancouver	31	.2	.0	.1	61	8.5
Whitehorse	16	.2	.0	.1	108	.5
Windsor	31	.4	.0	.1	58	4.4
Winnipeg	31	.3	.0	.2	107	1.4
Yellowknife	31	.2	.1	.2	101	.6
Network summary	718	0.6	0.0	0.2	64	3.0

NS, no sample.



Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program March 1968

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the

University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of 5 samples per month were needed to get a reliable average radioactivity at each station (7).

The maximum, minimum, and average beta radioactivity in surface air during March 1968 are presented in table 3.

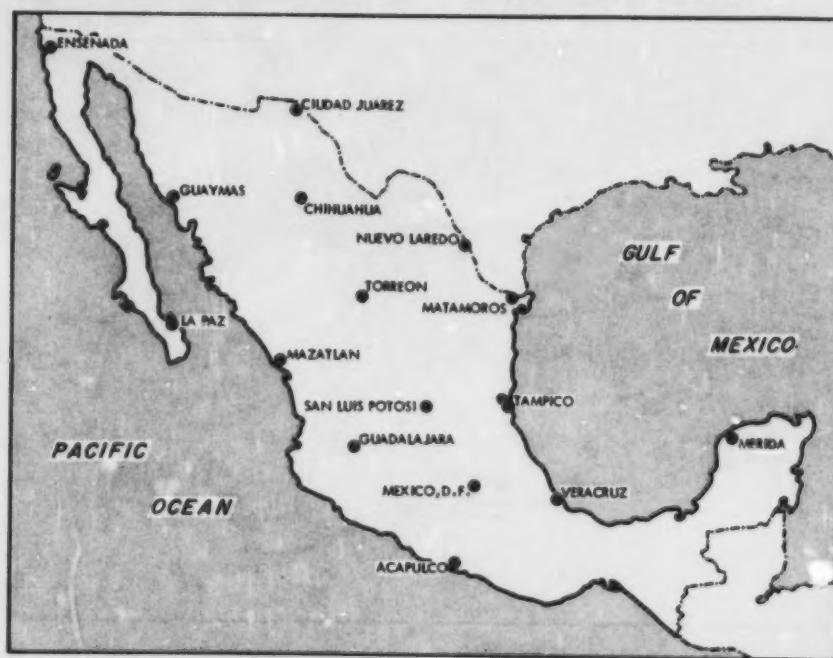


Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta radioactivity of airborne particulates, March 1968

Station	Number of samples	Gross beta radioactivity ($\mu\text{Ci}/\text{m}^3$)		
		Maximum	Minimum	Average *
Acapulco.....	15	0.8	0.2	0.3
Chihuahua.....	14	1.3	.1	.6
Ciudad Juárez.....	2	.5	—	—
Ensenada.....	1	.4	.4	—
Guadalajara.....	NB			
Guaymas.....	NB			
La Paz.....	5	.6	.2	.4
Matamoros.....	NB			
Morelia.....	8	1.0	.4	.6
Mérida.....	13	1.0	.1	.5
México, D. F.....	11	.9	.2	.5
Nuevo Laredo.....	5	.9	.2	.4
San Luis Potosí.....	NB			
Tampico.....	12	1.0	.1	.3
Torreón.....	15	.9	.1	.4
Veracruz.....	2	.6	.2	—

NB, no sample collected.

4. Pan American Air Sampling Program March 1968

*Pan American Health Organization and
U. S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the January 1968 *Radiological*

Health Data and Reports. The March 1968 air monitoring results from the participating countries are given in table 4.

Table 4. Summary of gross beta radioactivity in Pan American surface air, March 1968

Station location	Number of samples	Gross beta radioactivity ($\mu\text{Ci}/\text{m}^3$)		
		Maximum	Minimum	Average *
Argentina: Buenos Aires.....	16	0.03	0.01	0.02
Bolivia: La Paz.....	22	.03	.00	.01
Chile: Santiago.....	31	.03	.01	.02
Colombia: Bogotá.....	30	.07	.02	.05
Ecuador: Guayaquil.....	21	.04	.01	.03
Jamaica: Kingston.....	14	.36	.05	.30
Peru: Lima.....	12	.02	.01	.01
Venezuela: Caracas.....	17	.28	.05	.13
West Indies: Trinidad.....	19	.17	.06	.10
Pan American summary.....	172	0.36	0.00	0.06

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of less than $0.005 \mu\text{Ci}/\text{m}^3$ are reported and used in averaging as $0.00 \mu\text{Ci}/\text{m}^3$.



Figure 5. Pan American Air Sampling Program stations

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained

from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational

Safety in directives published in the AEC Manual.¹

Summaries of data from the environmental radioactivity monitoring reports follow for the Oak Ridge Area, and the Portsmouth Area Gaseous Diffusion Plant.

¹ Title 10, Code of Federal Regulations, Part 20 "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Oak Ridge Area January-June 1967²

*Union Carbide Nuclear Company
Oak Ridge, Tennessee*

Oak Ridge Area is a complex made up primarily of the Y-12 Plant, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in the Oak Ridge area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ability to fix radioactive materials by an ion exchange mechanism. Liquid wastes which contain long-lived

fission products are confined in storage tanks or are released to trenches located in the Conasauga shale formation. Low-level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

Air monitoring

Atmospheric contamination by radioactive materials occurring in the general environment of East Tennessee is monitored by two systems of monitoring stations. One system consists of nine stations which encircle the plant areas (figure 1) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of eight stations encircling the Oak Ridge area at distances of from 12 to 75 miles (figure 2). This system provides data to aid in evaluating local conditions and to assist in deter-

² Summarized from "Environmental Levels of Radioactivity for the Oak Ridge Area, January-June 1967," Health Physics and Safety Section, Health Physics Division, Oak Ridge National Laboratory.



Figure 1. Oak Ridge area environmental sampling locations

mining the spread or dispersal of contamination should a major incident occur.

Sampling for radioactive particulates is carried out by passing air continuously through a filter paper. Average concentrations are presented in tables 1 and 2. Airborne radioactive iodine is monitored in the immediate environment of the plant areas by passing air through a cartridge containing activated charcoal.

During the January-June 1967 surveillance period, 234 samples were collected from perimeter monitoring stations and analyzed for iodine-131. Of these, the maximum concentration detected was 0.12 pCi/m³, the minimum

was less than 0.010 pCi/m³, and the average was 0.018 pCi/m³. The radiation protection standard specified in the AEC Manual for iodine-131 in the ambient atmosphere in uncontrolled areas is 100 pCi/m³.

Milk monitoring

Raw milk is monitored for iodine-131 and strontium-90 by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of ORNL. Samples are collected weekly at each of eight stations located on the fringe of the Oak Ridge area.

Table 1. Long-lived gross beta radioactivity of particulates in air Oak Ridge area, January-June 1967

Perimeter stations				Remote stations			
Station number (figure 1)	Number of samples	Average concentration (pCi/m ³)	Percent of AEC standard *	Station number (figure 2)	Number of samples	Average concentration (pCi/m ³)	Percent of AEC standard *
HP-31	26	0.16	0.16	HP-61	26	0.21	0.21
HP-32	26	.26	.26	HP-62	26	.16	.16
HP-33	26	.14	.14	HP-63	26	.14	.14
HP-34	26	.13	.13	HP-64	25	.15	.15
HP-35	26	.14	.14	HP-65	26	.22	.22
HP-36	182	.25	.25	HP-66	26	.15	.15
HP-37	26	.11	.11	HP-67	25	.17	.17
HP-38	26	.20	.20	HP-68	26	.18	.18
HP-39	26	.23	.23				
Average		0.18	0.18	Average		0.18	0.18

* The applicable AEC Radiation Protection Standard is 100 pCi/m³.

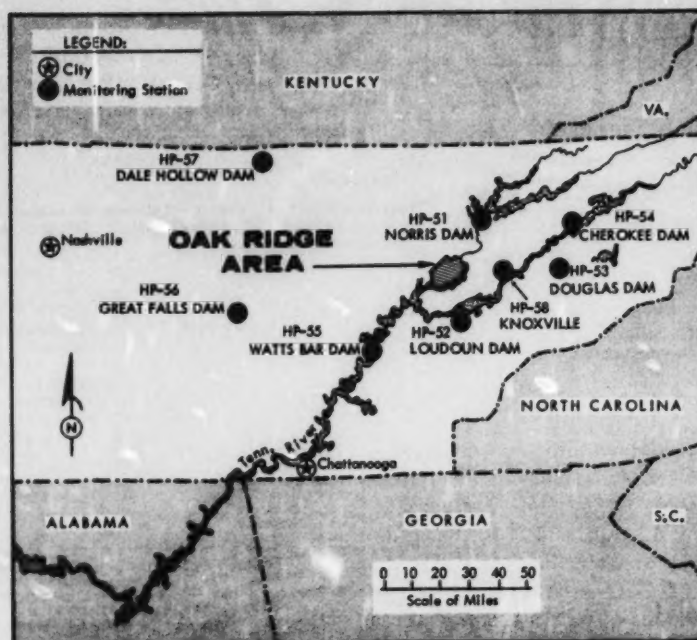


Figure 2. Remote air monitoring stations, Oak Ridge area

Table 2. Long-lived gross alpha radioactivity of particulates in air Oak Ridge area, January-June 1967

Perimeter stations				Remote stations			
Station number (figure 1)	Number of samples	Average concentration (pCi/m ³)	Percent of AEC standard *	Station number (figure 2)	Number of samples	Average concentration (pCi/m ³)	Percent of AEC standard *
HP-31	26	0.004	0.20	HP-51	26	0.004	0.20
HP-32	26	.007	.35	HP-52	26	.004	.20
HP-33	26	.004	.20	HP-53	26	.004	.20
HP-34	26	.003	.15	HP-54	26	.003	.15
HP-35	26	.007	.35	HP-55	26	.004	.20
HP-36	182	.016	.80	HP-56	26	.004	.20
HP-37	26	.005	.25	HP-57	25	.004	.20
HP-38	26	.004	.20	HP-58	26	.005	.25
HP-39	26	.006	.30				
Average		0.006	0.30	Average		0.004	0.20

* The applicable AEC Radiation Protection Standard for natural uranium in air is 2 pCi/m³.

Four stations, located more remotely with respect to the Oak Ridge operations, are sampled at a rate of one station each week. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of the Oak Ridge area provide data by which one may evaluate possible exposure to the neighboring population resulting from waste releases

from Oak Ridge operations; second, samples collected at the more remote stations provide background data which are essential in establishing the proper index for the evaluation of data obtained from local samples. The concentrations of iodine-131 and strontium-90 detected in raw milk samples during the period are given in table 3.

Table 3. Radionuclides in raw milk, Oak Ridge area, January-June 1967

Radionuclide and location	Concentration (pCi/liter)		
	Maximum	Minimum *	Average
Iodine-131:			
Immediate environs.....	930	<10	30
Remote environs.....	51	<10	8.2
Strontium-90:			
Immediate environs.....	59	4.5	27
Remote environs.....	40	5	24

* The minimum detectable concentrations of iodine-131 and strontium-90 in milk are 10 pCi/liter and 2 pCi/liter, respectively. In averaging, one-half of the minimum detectable concentration was used for all samples showing an activity less than this concentration.

Water monitoring

Large volume, low-level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River System by way of White Oak Creek and the Clinch River. Liquid wastes originating at the ORGDP and Y-12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with AEC radiation protection standards. The radioactivity concentration from White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tenn. Stream gauging operations are carried on continuously to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for the long-lived beta particle emitters, uranium, and the transuramic alpha-particle emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold up time in the waste effluent system are such that short-lived radionuclides are normally not present. The average concentrations of major radionuclides in the Clinch River are given in table 4 for the period from January through June 1967.

Two quarterly composite water samples from the Clinch River were analyzed for uranium during this period. For both samples, the

uranium concentrations were less than 1 pCi/liter, the level of detectability. The AEC radiation protection standard for natural uranium in water released to unrestricted areas is 2×10^4 pCi/liter.

Table 4. Concentrations of major radionuclides in the Clinch River, January-June 1967

Radionuclide	Average concentration (pCi/liter)		
	Location on Clinch River *		
	Mile: 23.1 ^b (Upstream)	Mile: 20.8 ^c (Outfall)	Mile: 4.5 (Downstream)
Strontium-90.....	0.5	0.7	1.0
Cerium-144.....	.2	<.1	0.2
Cesium-137.....	<.1	.4	1.6
Ruthenium-106.....	.4	1.2	.6
Cobalt-60.....	ND	.6	1.8
Zirconium-niobium-95.....	<.1	.1	.1
Gross beta.....	1.1	16	5.3

* The location on Clinch River is given in terms of the distance upstream from the Tennessee River, see figure 1.

^b Sampling station moved from Clinch River mile 41.5 to Melton Hill Dam CRM 23.1 about January 1, 1966.

^c The concentrations at miles: 20.8 are not measured directly but the values are calculated based on the levels of waste released and the dilution provided by the river.

ND indicates none was detected.

Gamma measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above the ground. The results are shown in table 5 in terms of mR/hr.

Table 5. External gamma radiation levels^a, Oak Ridge area, January-June 1967

Location	Average dose rates (mR/hr)
Solway Gate.....	0.011
Y-12, East Portal.....	.011
Newcomb Road.....	.011
Gallagher Gate.....	.010
White Wing Gate.....	.012
Five locations.....	0.011

^a The background in the Oak Ridge area, determined in 1943, was approximately 0.012 mR/hr.

Discussion of data

The average air contamination levels for gross beta radioactivity, as shown by the continuous air monitoring filter data, for both the immediate and remote environs of the plants

(figures 1 and 2) were 0.18 percent of the AEC radiation protection standard for populations in the neighborhood of a controlled area. These levels are 1.8 times higher than those for the last half of 1966.

The average air contamination levels for gross alpha radioactivity, as shown by the continuous air monitoring filter data, for the immediate and remote environs of the plants were 0.30 percent and 0.20 percent, respectively, of the AEC radiation protection standard for natural uranium for application to populations in the neighborhood of a controlled area.

The average concentration of iodine-131 in air in the immediate environs of the plants was 0.018 pCi/m³. This is approximately 0.018 percent of the AEC radiation standard for populations in the neighborhood of a controlled area.

The average concentrations of iodine-131 in raw milk in the immediate and remote environs of the Oak Ridge area were 30 pCi/liter and 8.2 pCi/liter, respectively. The maximum concentration observed, 930 pCi/liter, occurred on January 11, 1967, approximately 7 days after the arrival in the Oak Ridge area of fallout containing fresh fission products. The average values fall within the limits of FRC Range II if the average intake per individual is assumed to be 1 liter of milk per day.

The average concentrations of strontium-90 in raw milk in the immediate and remote environs of the controlled area were 27 pCi/liter and 24 pCi/liter, respectively. These levels fall near the lower limit of FRC Range II for

transient rates of daily intake of strontium-90 for application to the average of suitable samples of an exposed population.

The calculated average concentration of gross beta radioactivity in the Clinch River at mile 20.8 (the point of entry of most of the wastes) and the measured average concentration at mile 4.5 (near Kingston, Tenn.) were 16 pCi/liter and 5.3 pCi/liter, respectively. These values are 0.76 percent and 0.38 percent of the weighted average AEC radiation protection standards. The average concentration of transuranic alpha-particle emitters in the Clinch River at mile 20.8 was 0.10 pCi/liter which is approximately 0.005 percent of the weighted average AEC radiation protection standard.

The average activity of natural uranium materials in the Clinch River, reflecting the effects of all Oak Ridge plants, was less than 0.01 percent of the AEC radiation protection standard for natural uranium.

The average external gamma radiation measured in the town of Oak Ridge and at the perimeter of the Oak Ridge area was 0.011 mR/hr, which is approximately the same as that level measured during the period prior to Oak Ridge operations.

Recent coverage in *Radiological Health Data and Reports*:

<u>Period</u>	<u>Issue</u>
January-June 1966	January 1967
July-December 1966	August 1967

2. Portsmouth Area Gaseous Diffusion Plant³ July-December 1967

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium-234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. Since natural uranium is an alpha-particle emitter and thorium-234 is a beta-particle and gamma-ray emitter, environmental monitoring is conducted for evidence of alpha-particle, beta particle and gamma-ray emitters to test the effectiveness of plant controls.

Air samples are generally collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 3. Monthly water samples are collected at 13 stations within 5 miles of the plant.

For the second half of 1967, the waterborne beta-gamma radioactivity and the background exposure increased over the first half values. The airborne alpha, airborne beta-gamma, and the waterborne alpha radioactivity remained essentially unchanged. For calendar year 1967 versus calendar year 1966, all values remained

³ Data summarized from B. Kalman and S. H. Hulett: "Environmental Radiation Levels and Concentrations, Second Half and Annual Summaries 1967" (February 8, 1968).

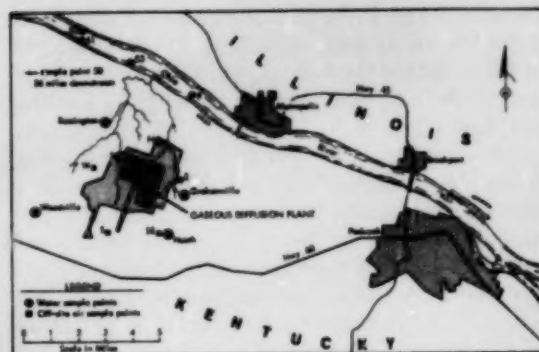


Figure 3. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

unchanged except for the waterborne beta-gamma radioactivity value which increased significantly. However, the 1967 value is only 0.24 percent of the AEC concentration standard.

Average background exposure rates remained unchanged from the 1966 values. In the calculations it is assumed that all of the exposure rates are attributable to plant operations. As in the past, the offsite and onsite patterns are very much alike in form and intensity with no significant differences between the average values. From the onsite and offsite intensities, it is evident that the plant operations have not added appreciably to the general background radiation.

Average alpha and beta-gamma radioactivity concentrations in air and water are summarized in table 6. The external gamma-radiation

Table 6. Environmental radioactivity, Portsmouth Plant, July-December 1967

Type of monitoring	Number of samples	Maximum	Minimum	Average	Average as a percent of AEC standard ^a
Air:					
Alpha radioactivity, pCi/m ³	122	0.5	<0.1	<0.1	0.23
Beta-gamma radioactivity, pCi/m ³	122	1.0	<.1	<.1	.01
Water:					
Alpha radioactivity, pCi/liter.....	61	170	<.5	15.8	.08
Beta-gamma radioactivity, pCi/liter.....	60	630	<14.0	56.8	.28
Background exposure^b					
mrads/hr.....	121	.020	.010	.015	17.9

^a The applicable AEC standards are as follows:

Air (alpha radioactivity) 2 pCi/m³
Air (beta-gamma radioactivity) 1x10³ pCi/m³
Water (alpha radioactivity) 2x10⁴ pCi/liter
Water (beta-gamma radioactivity) 2x10⁴ pCi/liter
External beta-gamma radioactivity 0.5 rem/yr (approx. 0.06 mrads/hr)

^b Measurements were made with an open-shield Gieger-Mueller tube 1 foot above ground. The 3-foot rate (not shown) was experimentally determined to average two-thirds of the 1-foot rate and was used to determine the percent of the AEC standard.

levels, measured at the air sampling locations shown in figure 3, are also summarized in table 6. The overall average concentrations and background exposure rates for 1966 and the first half of 1967 are presented in table 7 as percents of standards.

Recent coverage in Radiological Health Data and Reports:

Period	Issue
July-December 1966	September 1967
January-June 1967	January 1968

Table 7. Comparison of average concentrations Portsmouth Plant, 1966 and 1967

Type of monitoring	Percent of AEC standard *			
	1967			1966
	First half	Second half	Calendar year	Calendar year
Air:				
Alpha radioactivity.....	5.0	0.23	5.0	1.4
Beta-gamma radioactivity.....	0.02	.01	0.01	0.02
Water:				
Alpha radioactivity.....	.09	.09	.09	.09
Beta-gamma radioactivity.....	.20	.25	.24	.05
Background exposure extrapolated to 3 feet above ground level.....	^a 16.8	17.9	17.3	17.4

* See footnote (a) of table 6.

^a This value was reported in error as 17.5 for the first half of 1967.

Reported Nuclear Detonations, June 1968

The U.S. Atomic Energy Commission announced a nuclear test or low yield (20 kilotons or less TNT equivalent) was conducted underground at its Nevada Test Site on June 6, 1968.

The U.S. Atomic Energy Commission announced that the United States had twice recorded seismic signals originating from the Soviet underground nuclear test area in the Semipalatinsk region. On June 12, 1968, the signals were equivalent to those of a nuclear test in low yield range (less than 20 kilotons TNT equivalent) and on June 19, 1968, the

United States recorded seismic signals equivalent to those of a nuclear test in the low-intermediate range (20-200 kilotons TNT equivalent).

Announcements were also made by the U.S. Atomic Energy Commission of two nuclear tests of low-intermediate yield (20 to 200 kilotons TNT equivalent) that were conducted underground by the Atomic Energy Commission at its Nevada Test Site on June 15 and June 28, 1968.

50

SYNOPSIS

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

TRITIUM IN SURFACE WATERS OF THE UNITED STATES, 1966. A. A. Moghissi and C. R. Porter. *Radiological Health Data and Reports*, Vol. 9, July 1968, pp. 337-339.

During 1964, a tritium sampling network was established by the Public Health Service to measure the levels and consequently to determine the public health significance of tritium in surface waters of the United States. The analytical procedures used are described. Data for the samples obtained are presented. A means for estimating the radiation dose resulting from tritium in the body is developed. The calculations presented apply only to the areas sampled and cannot necessarily be extrapolated to other locations.

KEYWORDS: population, radiation dose, surface waters, tritium, tritium sampling network.

TRITIATED MOISTURE IN THE ATMOSPHERE SURROUNDING A NUCLEAR FUEL REPROCESSING PLANT. J. C. Daly, A. V. Manchester, J. J. Gabay, and N. I. Sax. *Radiological Health Data and Reports*, Vol. 9, July 1968, pp. 341-346.

A new wide-area sampling technique was used to collect more than 700 tritiated moisture samples over a 2-month period from seven sampling legs radiating out from a nuclear fuel reprocessing plant. For the 28 sampling periods studied, the average tritium radioactivity on the sampling leg northwest of the plant exceeded 2,500 pCi/liter, 75 percent of the time and exceeded 10,000 pCi/liter, 39 percent of the time as opposed to ambient levels of <2,500 pCi/liter. The highest tritium level recorded was 26,400 pCi/liter. These data are reported not so much for their epidemiologic value as for their value to public health agencies contemplating radiological surveillance around nuclear facilities.

KEYWORDS: atmosphere, nuclear facilities, nuclear fuel reprocessing plant, radiological surveillance, tritiated moisture.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 9, Number 8, August 1968

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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Department of Commerce
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Atomic Energy Commission

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RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

James G. Terrill, Jr., Director and
Dr. Raymond T. Moore, Deputy Director
National Center for Radiological Health

by the Standards and Intelligence Branch
Donald L. Snow, Chief

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Levels of Iron-55 in Humans, Animals, and Food, 1964-1967¹

H. E. Palmer^a, J. C. Langford^a, C. E. Jenkins^a, T. M. Beasley^a, and J. M. Aase^a

Iron-55 levels in the foods of humans have been decreasing since 1964 with the exception of caribou obtained from Arctic areas, which showed peak levels in 1965. The levels of iron-55 in humans at Richland, Wash., increased until about January 1967, and then began to decrease. This peak level in humans occurred about 4 years after the 1962 nuclear test series. This lag time of 4 years is much longer than that for cesium-137 in humans where peak levels occurred 1½ years after the nuclear tests stopped.

The relatively high abundance of the activation product iron-55 in the fallout from the 1961-1962 nuclear tests resulted in a deposition of this isotope on the earth's surface which at one time was comparable to or slightly higher than the strontium-90 and cesium-137 levels (1). However, the relative amount of iron-55 in the environment has decreased much more rapidly than strontium-90 and cesium-137 because of its shorter half-life of 2.4 years.

Because of the high uptake of fallout iron-55 in the food chains leading to humans, it can be measured in people all over the world (2, 3, 4). Although the energy of the radiation emitted as a result of the disintegration of an atom of iron-55 is small, it is of interest because most of the radiation dose is absorbed by the red blood cells of the body (5).

The two main routes of iron-55 to humans are the terrestrial food chain of plant to animal to man and the marine food chain from sea water through the lower trophic levels to fish to man. The purpose of this paper is to discuss the levels of iron-55 in the components of these food chains, and the changes in these levels during the past few years, and to compare the

rate of uptake by man of this isotope with that of cesium-137.

Iron-55 in the marine environment

A preliminary survey of iron-55 in the most common foods consumed by people showed that ocean fish contain a higher concentration of iron-55 than do many other foods (3). Salmon and tuna were among the fish having the highest concentrations. For both of these fish the concentrations increased in the more northern latitudes. This change in concentration with latitude has been observed for the past 4 years and table 1 lists the levels in salmon at various locations. The highest concentrations observed in salmon were from those caught at Kotzebue, Alaska.

Table 1. Levels of iron-55 in salmon caught at various locations from 1965 to 1967

Sampling location	Average (nCi iron-55/kg of wet muscle)		
	1965	1966	1967
Northeast Alaskan coast.....	(2) 50	(44) 19	(10) 5.0
Southern Alaskan coast.....	(4) 33	(14) 25	(17) 5.6
Washington State coast.....	(2) 9.0	(6) .91	(10) 1.5

* Numbers in parentheses are the number of salmon included in the average.

The data in table 1 are averages of several species and include silver, sockeye, chinook, and chum salmon. Our studies do not yet show any definite differences in iron-55 content in any particular species. The decrease of iron-55 in

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^a Pacific Northwest Laboratory, operated by Battelle Memorial Institute for the Atomic Energy Commission, Richland, Wash.

^a Arctic Health Research Center, Anchorage, Alaska. Present address: University of Washington Medical School, Seattle, Wash.

the salmon with time is about the same or slightly more rapid than the decrease in the fallout rate, as measured from air and rain concentration, both in the United States and Alaska. This suggests that the iron-55 deposited in the ocean may be rapidly taken up by the biomass and becomes relatively unavailable for further recycling into the salmon.

Other recent studies (6) confirm our results of yearly decreases in salmon levels since 1964 and the increased concentration at northern latitudes. The reason for the relatively high iron-55 levels in salmon is not entirely clear and the route of intake has not been well established. Recent studies at our laboratory have shown that the iron-55 specific activity in salmon (μCi of iron-55/g stable iron) is 1,000 to 10,000 times greater than in the particulate fraction of sea water. Iron is present in sea water in about half particulate and half soluble form (7). This sea water was filtered through a 0.3 micron pore size membrane filter at a point 15 miles off the northern California coast away from any major river influence where the salinity and the stable iron content were normal. This suggests again that the iron-55 from fallout is in a form which is more readily available for uptake in the marine food web than the stable particulate iron in the ocean.

Iron-55 in humans

It has been shown that whole population groups including the Japanese, the Scandinavians and the Southeast Alaskan Eskimos, who eat large quantities of ocean fish, have far higher iron-55 body burdens than the average for other people in the world (3, 4). It has also been observed that females of these population groups have higher burdens than the males and that the specific activity of iron-55 remains constant on transfer from mother to fetus. The nature of this transfer of iron-55 from mother to fetus was characterized in a study during 1967 of 50 mother-fetus pairs from an area surrounding Dillingham, Alaska (results to be published elsewhere). The specific activity of the mother's blood was essentially the same as that in the baby's cord blood at birth except in 2 or 3 cases. The average

specific activity for all the mothers and all the newborn babies was approximately 0.10 nCi/mg when decay was corrected to January 1967. Assuming a total iron content of 4,000 mg, the average body burden was 400 nCi for the adult females in that area during January 1967, as compared with an average body burden of 700 nCi measured in a similar group of fish-eating female natives from the Bethel Alaska area in early 1966.⁴

Iron-55 in the terrestrial environment

The main source of iron-55 in the diets of most of the people of the world is from meats and grains. The decrease of iron-55 with time, resulting from the plant to animal to man food chain is shown in table 2 where the levels of

Table 2. Total body iron-55 contents^a in 1,000 lbs. steers raised near Richland, Wash., 1964-1966

Sampling date	Number of steers	Average body burden (nCi)
November 1964.....	8	441
November 1965.....	4	226
December 1966.....	10	108
March 1968.....	20	44

^a Body burden determined from blood samples by assuming 60 percent of iron is in the blood.

iron-55 in the blood of cattle near Richland, Wash., are listed for the years 1964-1966. This decrease with time in the iron-55 content of cattle is slightly less than the decrease in fallout rate. This relationship is probably due to the fact that grass and other cattle feeds collect most of their iron-55 directly from the atmosphere. The iron-55 which reaches the soil undergoes tremendous dilution by stable iron in the soil, and only a small fraction is absorbed by the plants. An exception to this type of relationship is the food chain of lichen to caribou to man where the lichen does not die off each year but collects and holds a large fraction of the fallout for a period of years and provides a more concentrated source of iron-55 to the caribou. For this reason, the caribou blood levels increased for a period of years and then decreased as the radioactive decay exceeded the deposition of iron-55 on the lichen from fallout (table 3).

⁴ Considering the 2.4-year half-life of iron-55, this reduction is close to the value based on physical decay.

Table 3. Total body iron-55 * in caribou from Anaktuvuk Pass, Alaska, 1964-1967

Sampling date	Number of caribou	Average body burden (nCi)
November 1964.....	5	744
February 1965.....	6	714
October 1965.....	6	953
May 1966.....	6	654
January 1967.....	10	670
March 1968.....	6	481

* Body burden determined from blood concentration by assuming 60 percent of iron is in the blood.

Iron-55 in foods and humans

The decrease in iron-55 levels in common foods purchased at local Richland, Wash. stores between December 1964 and April 1967 are shown in table 4. This time interval is 2.4 years which is the same as the half-life of iron-55 and, therefore, the 1967 results can be multiplied by a factor of 2 to correct for the radioactive decay since 1964. If this is done the overall average for the foods measured in this study for 1967 would be about the same as the overall average in foods for 1964. This result does not agree with those obtained in the cattle (table 2) and salmon (table 1) where the concentrations are significantly lower in 1967 even after a decay correction is made. One possible explanation for the similarity between the results for the 1964 grain product samples and the 1967 samples is that the earlier samples may have been from stored grain which had

been harvested prior to the 1962-1963 peak fallout levels. Another possible explanation for the similarity is that the geographical source of the raw materials differed in 1964 from 1967.

The body burdens of iron-55 in people in Richland, Wash., have been determined for the past 4 years by measuring the levels in blood samples taken at hospitals and Red Cross blood drawings. The blood left in the plastic tubing after the blood samples are taken in blood donations is sufficient for measuring iron-55 if these are collected and combined for at least 25 people. The body burdens in Richland adults at various times are listed in table 5. The four people in the first two samplings were the same people and it is obvious that their average body burdens of iron-55 were lower than the average for 100 men obtained a few months later. The results do demonstrate an increasing body burden until the July 1967 sample which showed that the levels had started to decrease. The similarity of the Richland female and male body burdens is typical of results obtained from blood bank samples. Previous sampling of non-blood bank male and female blood indicates that iron-55 levels measured in females may be two times higher than males of the same population (2). These differences indicate that the iron uptake and turnover in women is significantly greater than in men. Consequently, the iron-55 activity in females after the initial environ-

Table 4. Comparison of iron-55 in various foods purchased at Richland, Wash., in 1964 and 1967

Food	1964			1967		
	Stable iron	Iron-55	Specific activity	Stable iron	Iron-55	Specific activity
	(mg/kg)	(nCi/kg)	(nCi/mg)	(mg/kg)	(nCi/kg)	(nCi/mg)
Beef, round steak.....	23	0.70	0.030	23	0.24	0.010
Beef, liver.....	70	1.1	.016	100	1.45	.015
Bologna.....	9.1	.34	.037	14	.083	.006
Weiners.....	12	.21	.018	25	.33	.013
Pork chops.....	6.7	.013	.002	10	.007	.0007
Pork and ham loaf.....	16	.060	.004	9.7	.047	.005
Washington coast: Salmon.....	5	3.42	.68	11	1.5	.14
Pacific ocean: Tuna.....	4.6	5.8	1.26	8.6	3.7	.43
Clams.....	17.7	.045	.003	26	.046	.003
Oysters.....	170	.087	.0005	68	.075	.001
Whole wheat flour.....	38	.20	.008	38	.23	.006
White flour.....	31	.044	.001	40	.006	.0002
Wheat flakes.....	56	.25	.004	54	.12	.002
Quaker oats.....	41	.15	.004	52	.093	.002
Eggs.....	23	.25	.011	23	.013	.0006
Lettuce.....	4.5	.011	.002	8.5	.0014	.0002
Carrots.....	4.1	.028	.007	8.4	.0006	.00007

mental exposure would reach a maximum earlier than males and then rapidly decline to levels below the male population. Women who have the highest iron uptake are usually those who are more anemic and these women are not allowed to donate at blood banks. Therefore, blood bank samples do not represent the average iron-55 levels in women, and it is also possible that regular male blood donors do not represent the normal population since their regular blood loss through donation will increase their rate of iron turnover.

The body burdens in the male Eskimos on caribou diets at Anaktuvuk Pass, Alaska, increased during 1965; body burdens of 61 nCi were observed in January and 81 nCi in November. Samples at later dates have not been obtained, but the levels in the caribou which they eat and the long biological half-life in the body suggests that the levels in these Eskimos have continued to increase until recently.

Although the major nuclear testing by the United States and U.S.S.R. was stopped in 1962, the levels in humans in Richland, Wash., did not reach peak values until the latter part of 1966 or early 1967. This 4-year lag is probably caused by (1) the time for the fallout to reach the earth's surface and transfer through the food chain, and (2) the long biological half-life in humans which allows the levels in humans when not near the equilibrium level, to continue to increase for a period of time after the levels in the food have begun to decrease. This lag time is about 2½ years longer than that for cesium-137 in humans in Richland, Wash., where the peak levels were reached during mid 1964. This is reasonable when the shorter biological half-life of cesium-137 in humans and in the various components of the food chain is considered. If the iron-55 levels

are corrected for radioactive decay, the lag time for the peak levels in humans after injection of iron-55 in the atmosphere would be somewhat longer than that shown by the actual levels.

Summary

Iron-55 levels in fallout and most foods have been decreasing since 1964. The relative decrease in some of these components of the human food chain and fallout is shown in figure 1. The levels in humans have been increasing until recently when they showed a decreasing trend.

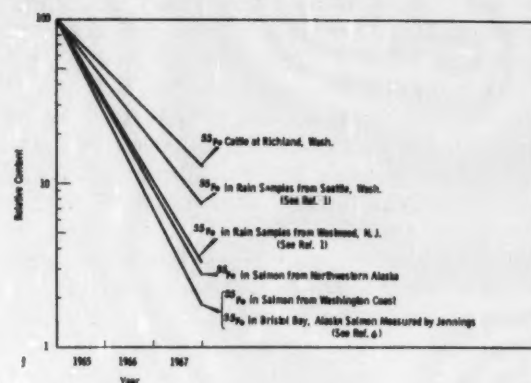


Figure 1. A comparison of the relative decrease of iron-55 in fallout, salmon, and cattle

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Table 5. Total body iron-55 in adults in Richland, Wash.

Sampling date	Male		Female	
	Number of individuals in composite samples	Average body burden (nCi)	Number of samples	Average body burden (nCi)
November 1964.....	4	9	—	—
October 1965.....	4	13	—	—
January 1966.....	100	21	25	16
March 1966.....	—	—	25	18
December 1966.....	100	24	25	22
July 1967.....	84	17	—	—

Cesium-137 Levels in Florida Beef—Variations With Feeding Program¹

C. E. Roessler, B. G. Dunavant, H. A. Bevis, and G. S. Roessler²

Levels of cesium-137 in low quality lean beef samples, collected in the vicinity of Gainesville, Fla., in the spring of 1967, averaged 4,000 pCi/kg and ranged from 290 to 12,500 pCi/kg. The average and maximum levels in these samples from eight grass-fed animals were considerably higher than those in samples from 26 grain-fed animals from five peninsular Florida feedlots. The levels in the grass-fed animals suggest very high levels of cesium-137 intake by the animals, an extremely high feed-to-meat transfer, or both. For persons whose meat consumption is represented by the grass-fed animals examined in this study, it can be expected that meat exceeds all other commodities as the source of cesium-137 intake.

This paper reports observations of the effect of feeding program and associated meat quality on the levels of environmentally accumulated cesium-137 in Florida beef sampled during 1967 (figure 1).

From examination of reported data, it appears that cesium-137 levels in Florida milk have a consistent geographic pattern (1).³ This impression can be confirmed by statistical testing and similar patterns can be found in feedlot beef.⁴ Levels in these two media in peninsular Florida (the general area encompassing the northeastern, central, and southern parts of the State) were higher than in the western part of the State and were higher than reported or anticipated average levels in comparable media from the conterminous United States.

Porter has reported that cesium-137 levels in milk from the Tampa, Fla. milkshed have considerable farm-to-farm variation (2); in other studies, this variation has been found throughout the State.⁵ These variations have

been attributed to variations in levels of cesium-137 intake by the animals, and locally grown forages have been identified as major contributors to the elevated intake of this nuclide.

During a study of geographic variations in feedlot beef,⁴ some examples were collected also from lower grade carcasses of animals whose feed included various amounts of grass. This provided an opportunity to determine whether feed source has the same effect on cesium-137 levels in Florida beef as it apparently has on levels in milk.

Methods

During the spring of 1967, samples from eight locally fed animals were obtained from a commercial packing plant in the Gainesville,

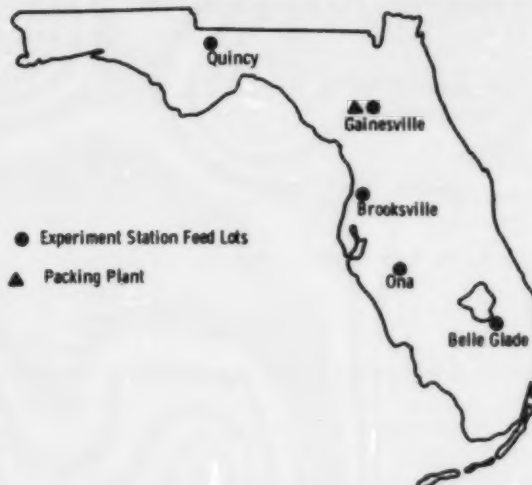


Figure 1. Florida beef sampling locations

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² Dr. C. E. Roessler is assistant professor of Radiation Biophysics (Department of Radiology); Dr. Dunavant is director and professor of Nuclear Sciences; Dr. Bevis is associate professor of Environmental Engineering; and Mrs. Roessler is instructor in Nuclear Sciences, University of Florida, Gainesville, Fla. 32661.

³ C. E. Roessler, E. G. Williams, and E. D. Nettles, University of Florida and Florida State Board of Health, submitted for publication.

⁴ C. E. Roessler, B. G. Dunavant, and H. A. Bevis, to be published in *Health Physics*.

⁵ Work performed at Florida State Board of Health and at the University of Florida.

Fla. vicinity. This meat was of a lower quality than meat usually sold as retail cuts and was intended for ground beef and meat products (frankfurters, bologna, etc.). Four of these samples were collected in April and were identified only as "two had some grain, two fed primarily grass." In May, the four additional samples were collected from the same packing plant along with available identifying information. All of these latter animals were cows of various breeds, the meats were low grades, and two samples were specifically identified as from grass-fed animals while two were from animals that had some grain. The packing plant samples were collected in the cutting room from animals selected by plant personnel and when picked up in the shipping department were not identified as to portion of animal. The assumption was made that the cesium-137 content of any lean portion sampled was representative of consumed lean tissues of that animal and could be compared with results from analysis of different portions of other animals.

Samples were also collected during January through June 1967, from 26 carcasses graded USDA Good or USDA Choice from animals fed

at Florida Agricultural Experiment Station feedlots at the five locations shown in figure 1.^a Two of these latter animals were from a feedlot in the Gainesville vicinity. The other animals were from sites scattered throughout peninsular Florida. (See part C of table 1). These samples were obtained through the University of Florida Meat Laboratory; the carcasses were sampled by collections of the portion associated with the 13th rib (3 to 4 inches of a short loin).

Samples were prepared for analysis by boning, trimming the excess fat, and grinding the trimmed lean portion.

Analyses for cesium-137 and potassium-40 were performed by gamma-scintillation spectrometry followed by quantitative evaluation of the gamma-ray spectra using the method of simultaneous equations. Cesium-137 concentrations were reported as picocuries per kilogram (pCi/kg) and as picocuries per gram of potassium (pCi/g K).

Results

As shown in part A of table 1, the first four packing plant samples (Nos. 36-39) had cesium-137 contents ranging from 290 to 12,500

Table 1. Variation of cesium-137 content of lean Florida beef as influenced by feeding program and grade of meat

Sample number	Animal description	Feed	Meat grade	Cesium-137 (pCi/kg)	Potassium (g/kg)	Cesium-137/potassium (pCi/g)
A. Samples from local packing plant buying only local animals (trimmed from unidentified portions) ^b						
Collected April 26, 1967						
36	4 animals identified only as "two had some grain, two fed primarily on grass"			293 ± 24	3.24 ± .24	90.4 ± 9.9
39				507 ± 29	3.51 ± .27	144.0 ± 13.7
37				1,840 ± 36	3.69 ± .27	498.0 ± 37.8
38				12,500 ± 73	3.36 ± .28	3,710.0 ± 309.0
Collected May 10, 1967						
50	Hereford cow	Some grain	Utility	567 ± 27	3.90 ± .26	145.0 ± 12.0
53	Hereford cow	Some grain	Cutter	808 ± 41	4.09 ± .38	198.0 ± 21.2
52	Jersey-cross cow	Grass-fed	Not specified	5,530 ± 68	4.97 ± .40	1,130.0 ± 97.2
51	Brahma cow	Grass-fed	Canner	9,840 ± 64	3.62 ± .37	2,720.0 ± 200.0
			Average of 8 animals	3,900	3.80	1,080.0
			Range	293 - 12,500	3.24 - 4.97	90.4 - 3,710
B. Samples from University of Florida Beef Research Unit (trimmed from short loin)						
Collected January 7, 1967						
7	Steer	Dry lot: corn, and Citrus pulp	Good	204 ± 29	3.75 ± .30	54.3 ± 8.9
8	Steer		Good	142 ± 34	3.31 ± .24	42.6 ± 7.8
			Average of 2 animals	173	3.53	48.5
C. Samples of feed-lot animals from five peninsula Florida stations (trimmed from short loin)						
Collected January-June 1967						
	Steers and heifers	Dry lot	Good and choice	240	3.58	66.1
			Average of 26 animals	109 - 530	3.09 - 4.22	30.4 - 133.6
			Range			

^a Confidence intervals represent the two-standard deviation counting error only and do not include other sources of variance.

^b Comments concerning feed of these animals were supplied by packing plant. They are probably based on condition of animals and appearance of meat.

pCi/kg (90 to 3,710 pCi/g K). These four samples from the same general geographic locality had a wider range of cesium-137 levels than all the statewide beef samples analyzed previously in this laboratory. Type and source of feed seemed to be the most likely explanation for the degree of variation, and it was suspected at this point that the highest cesium-137 levels were from the animals whose diets were composed primarily of grass. In order to verify that such a wide variation in results was not a rare chance occurrence, the four additional samples (Nos. 50-53), also listed in part A of table 1, were collected from the same source. It can be seen that the range of results was very similar to the previous four samples. Among these samples, the animals identified as totally grass-fed did indeed have the highest cesium-137 levels.

By contrast, it can be seen from part B of the table that the two feedlot samples from the same vicinity (Nos. 7 and 8) had cesium-137 levels of 200 and 140 pCi/kg (54 and 43 pCi/g K), respectively. The range of results from the lower quality samples also contrasts sharply with the combined results from the entire 26 samples from feedlot animals as presented in part C of table 1. These samples had an average cesium-137 concentration of only 240 pCi/kg, and the values ranged from 110 to 540 pCi/kg.

Discussion of results

There is a pronounced difference between cesium-137 levels in USDA Good and USDA Choice meat from feedlot animals and the levels in lower quality meat from animals identified as having been fed on various amounts of grass. Although the magnitude of difference is much greater, the direction of difference is similar to that observed by Ward and Johnson in 1963 (3). They found that levels in meat from dairy cows and calves on pasture or hay were about three times as high as those in meat from dairy cows on hay and grain and in meat from feedlot animals.

In a given animal species, the levels of environmentally acquired radionuclides are influenced primarily by the dietary intake of these radionuclides. Among the cattle feeds, forages

have been reported to have cesium-137 concentrations that are about an order of magnitude higher than those in grain and other feeds (3). This has been observed in the Tampa milkshed (2) and in other parts of the State.^a Hay and forage should then be the primary sources of cesium-137 for animals whose diets include significant amounts of these feeds. A reasonable upper limit for Florida grasses might be taken from the work of Porter et al. (2), who reported Tampa pangola grass ranging from 3,700 to 9,600 pCi/kg (dry weight) in 1963-1964.

Ward and Johnson also attributed differences in meat concentrations to differences in the transfer coefficient^a from diet to meat for this nuclide (3). Although unable to separate completely the influence of age, diet composition, and type of animal, they reported transfer coefficients from diet to meat that were higher for beef animals in the feedlot (0.03) than for dairy cows (less than 0.01) and were highest for younger animals (0.04 to 0.1 for 6-month-old calves on pasture).

Either the feed concentration, the transfer from feed to meat, or both, must have been extremely high in the case of several of the animals sampled in this study. The highest radionuclide concentrations observed in meat (on the order of 10,000 pCi/kg) can be predicted for an equilibrium situation by using an extreme cesium-137 concentration in grass of 10,000 pCi/kg and an extreme transfer coefficient of 0.1 and by assuming an intake of 10 kg (dry weight) of grass per day.

Possible sources of high intake, over and above that due to the grass levels quoted, may have been poor pastures where the animals were forced to browse on close-growing plants or plant portions in the litter. Cesium-137 levels have been reported to be much higher in the root mat than in the grass in Midwest grassland; the findings of levels of this nuclide 3 to 50 times higher in caribou than in moose in the same areas of Alaska and Canada have been attributed to the greater utilization of lichen and possible plant litter in the caribou diet (4, 5). Higher than expected intakes might

^a Transfer coefficient = radioactivity concentration per kilogram of meat/daily intake of radioactivity.

also result where animals have access to the epiphyte, Spanish moss (*Tillandsia usneoides*). Investigators in this laboratory and Porter et al. (2) have found the cesium-137 levels in this medium to be among the highest in the Florida environment.

The levels of cesium-137 in grass-fed Florida beef were compared with reported concentrations in meat from various selected situations as summarized in table 2. The average of the eight samples from grass-fed animals, 4,000 pCi/kg, is an order of magnitude higher than the average reported by Ward and Johnson (3) for pasture animals in 1963 at Fort Collins Colo., and the highest value found is about 36 times their highest reported value. These extreme values are comparable to what has been reported for cattle in Norway and approach those reported for reindeer and caribou in the Arctic (5-10). The higher values are also comparable to the average level reported by Plummer for cesium-137 in Georgia deer browsing in the wild (11).

It has been estimated that meat and milk contribute about equally as the principal sources of cesium-137 intake for persons who drink Florida milk and whose total meat consumption contains the average levels of cesium-137 found in meat from feedlot beef in peninsular Florida.⁵ The data reported here indicate that if the majority of meat consumed had cesium-137 levels equal to the average observed in the low-quality samples analyzed in this study (about 4,000 pCi/kg), this commodity would greatly exceed all other food categories as the source of cesium-137 intake.

In conclusion, levels of cesium-137 in beef from grass-fed animals in Florida appear to be much higher than those in grain-fed animals. Since the former usually produce lower-grade carcasses, intake of this nuclide by humans will vary inversely with the quality of beef consumed. Therefore, one would expect body burdens in humans to be inversely related to the economic status of the family, a relationship suggested previously by Ward and Johnson (3).

Table 2. Some recently reported cesium-137 levels in various meats

Investigator	Reference number	Meat-description	Location	Date	pCi/kg		
					N ^a	$\bar{x}$ ^b	R ^c
Rossier:.....	—	Lean beef (Cutter, canner, utility grades; grass-fed)	North Central Florida	Jan-June 1967	8	3,900	293-12,500
	(4)	Lean beef (Good and choice; feedlot)	Florida-Statewide "Peninsular" Florida		33	214	55- 539
Ward and Johnson:....	(5)	Feedlot beef	Ft. Collins, Col.	1963	26	240	109- 539
	(6)	Dairy cows on hay and grain			44	101	
Tri-City Study:.....	(12)	Dairy cows, calves on pasture			9	114	24- 173
Anonymous:.....	(14)	Meat (home produced and imported)	3 U. S. Cities	1965	11	330	116- 578
Madhus:.....	(8,10)	Beef	United Kingdom	1965	—	217	93- 338
			Southwest Norway	Late fall, 1964	—	280	
Hvinden:.....	(7)	Beef	Southwest Norway		—	900	300- 2,600
		Reindeer	North Norway		—	2,500	1,600- 4,400
Miettinen:.....	(9)	Reindeer meat	Norway	1965	—	2,300	800- 4,100
			Finnish Lapland		—	1,700	
Chandler and Snavely:..	(8)	Caribou meat	Alaska	Winter 1960	—	71,000	
		Reindeer meat		Winter 1961	—	35,300	
Anonymous:.....	(8)	Caribou meat	Alaska	1961	—	18,000	7,400-18,000
		Reindeer meat		December 1963	132	13,800	400-57,000
Madhus:.....	(10)	Reindeer	Norway	April 1966	132	18,000	2,080-47,000
Plummer:.....	(11)	White-tailed deer in the wild	Georgia	March-May 1967	15	19,000	11,000-31,000
Brar and Nelson:.....	(13)	Beef	Chicago	1964-1965	15	24,000	13,000-46,000
				1966	10	33,500	10,800-51,200
				January 1967	—	9,000	
				April 1967	—	28	
				July 1967	—	19	
					—	46	

^a N = number of samples, where reported.

^b $\bar{x}$ = average content.

^c R = range of reported values.

^d To be published in Health Physics.

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Technical Notes

Thermoluminescent Radiation Dosimetry Applied to Dental X-Ray Exposures

John R. Howley, Charles Robbins and Mardalee B. Dickinson¹

For a little more than a decade, dentists in hospitals and clinics have been developing a panoramic radiographic technique which produces a full-mouth radiograph on a single strip of film (figure 1). An excellent summary of this technique is given by Updegrave (1). During this x-ray procedure, the patient's head remains stationary while the film and the x-ray source, each mounted on opposite ends of a metal support, rotate around the patient's head (figure 2). At the half cycle, the axis of rotation is changed in order to position each side of the patient's head symmetrically with respect to the film and also to minimize distortion. A special value of panoramic radiography over the conventional, full-mouth, periapical, radiographic

survey is that no film is placed in the mouth of the patient so there is no discomfort. This procedure can also be used to show the status of development and eruption of teeth at various ages. Since the procedure uses intensifying screens and increased object-to-film distance, the definition and detail are relatively poor. Consequently, this procedure is limited to those situations where clarity is not essential. Panoramic radiography is not intended to replace conventional periapical radiography, but rather to complement it (1-3).

¹ Messrs. Howley and Robbins and Mrs. Dickinson are health physicists with the Radiation Safety Section, Department of Nuclear Medicine, National Institutes of Health, Bethesda, Md. 20014.

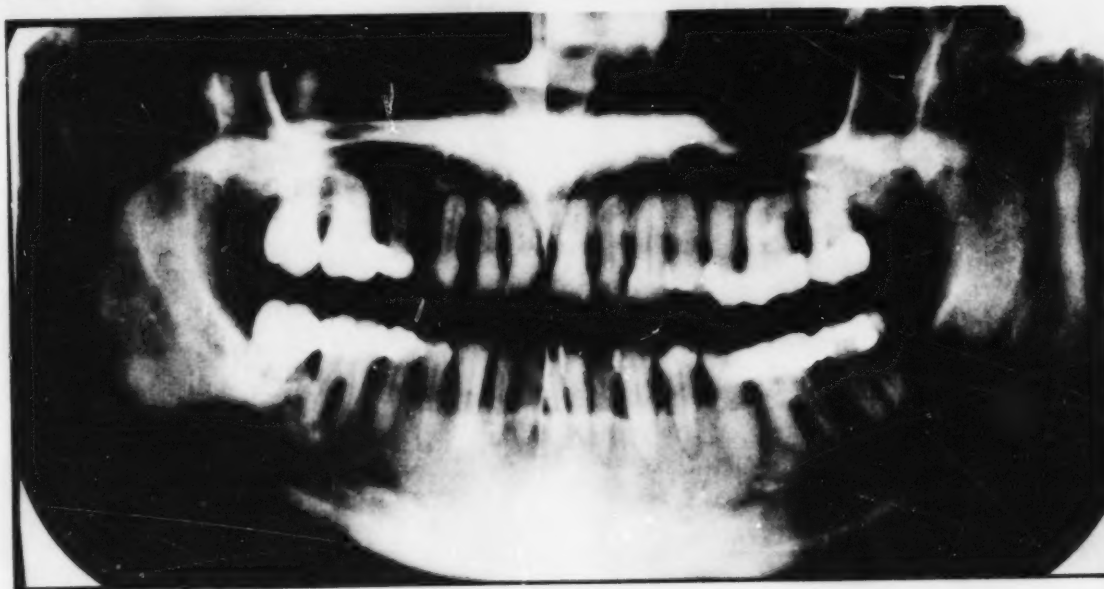


Figure 1. A full mouth x-ray by panoramic technique

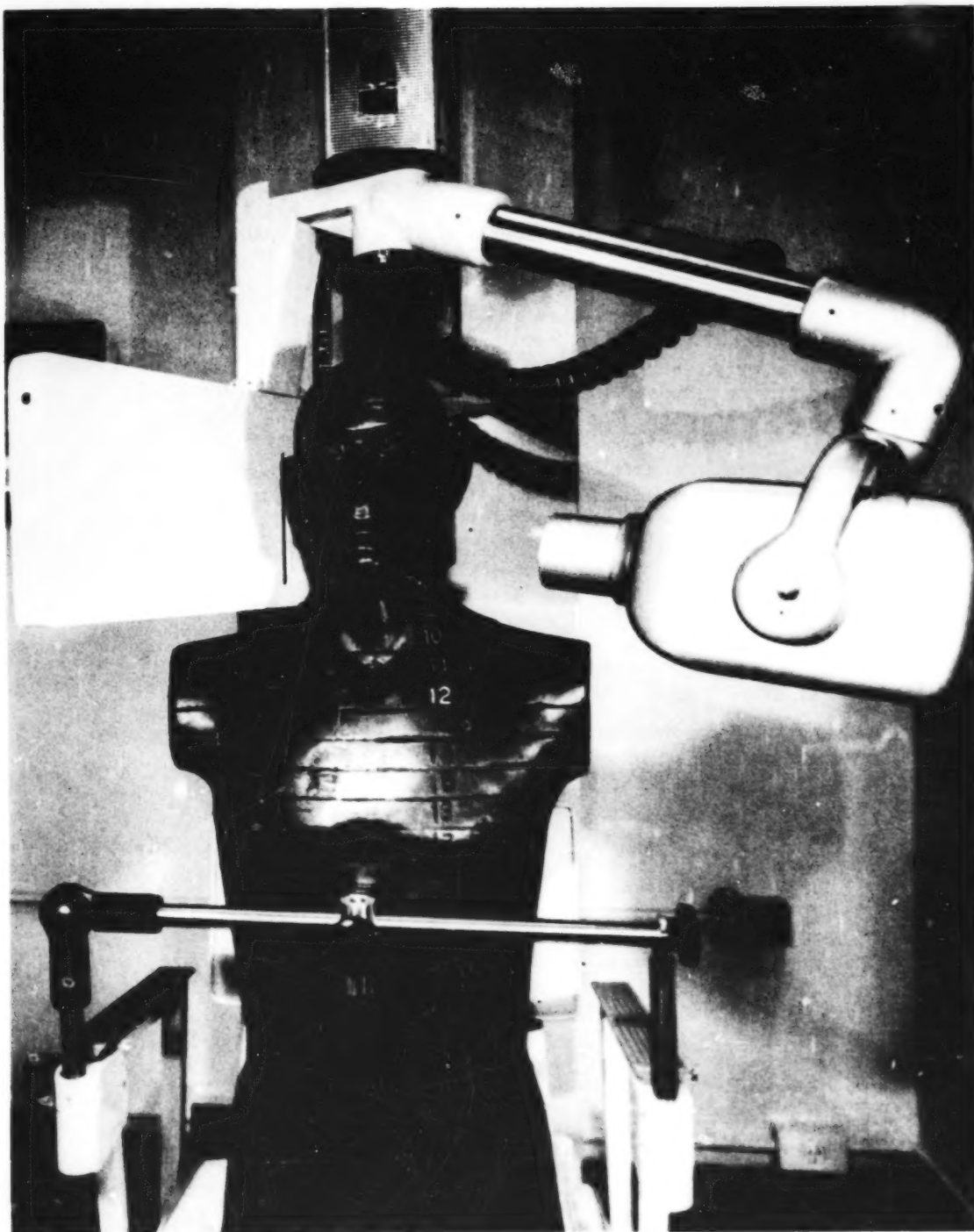


Figure 2. A Rando human phantom and the Panorex dental x-ray unit

Contrasted with the above is the conventional full-mouth x-ray examination which consists of 7 exposures to the upper jaw and 7 exposures to the lower jaw, with dental film placed in the mouth of the patient.

The purpose of this study was to demonstrate the use of thermoluminescent dosimeters in these diagnostic techniques. It was also of interest in making radiation safety surveys to compare the patient radiation exposures from the panoramic technique with the exposure from the conventional technique.

The problem

The rotating narrow x-ray beam used in panoramic dental radiography introduces some complications in the radiation dosimetry measurements (4). Dosimetry with film is hampered by energy and directional dependence primarily due to scattered radiation (5). Dosimetry by ion chamber techniques is limited by the necessity for uniform irradiation of the entire sensitive volume (4, 6-8). The problem of panoramic dosimetry is one of measuring the radiation exposure from a very narrow beam of primary x rays plus scattered radiation.

Method

Miniature glass encapsulated lithium fluoride thermoluminescent dosimeters (TLD), figure 3, placed at selected locations within a Rando human phantom were exposed to radiation from a single film panoramic (Panorex) x-ray procedure and to radiation from a conventional full-mouth dental x-ray procedure, for the purpose of comparison. The panoramic radiographic procedure, as practiced at the National Institutes of Health, involved a 30-second rotational exposure at 10 mA and 80 kVp. The half-value layer of this beam was 1.5 mm of aluminum. The conventional procedure consisted of 14 exposures to selected positions about the jaw at 65 kVp, 10 mA and 0.8 second per exposure. The x-ray tube target-to-skin distance for the conventional unit was 18 inches. The half-value layer of the x-ray beam was 2 mm of aluminum. The diameter of the useful x-ray beam from the conventional unit was approximately 3 inches at the tip of a 16-inch beam collimator,



Figure 3. The glass encapsulated lithium fluoride thermoluminescent dosimeter

in contrast with a 3-inch-long by 0.25 inch wide x-ray beam from the Panorex unit at an x-ray tube target-to-skin distance of 12 inches.

Thermoluminescent dosimeters were chosen for this study because they minimize the problems of energy and volume dependence (9-11) which are associated with the other dosimeter types considered. Directional dependence remained a complication. A 25 percent reduction in reading was observed for exposures to the smaller surface of 1.4 x 12 mm dosimeters compared with similar exposures to the larger surface. A major difficulty in low dose dosimetry with TLD in the past has been background interference, principally from electronic noise. Recent improvements in these systems have reduced this difficulty to a minimum. Exposures in the milliroentgen range were measured with a background, including noise, of less than 2 mR. The glass-encapsulated dosimeters were uniform, reasonably rugged and required no prior annealing or nitrogen atmosphere for low exposure measurements. Dosimeters exposed to 50 mR had a standard deviation of 3 percent. Readings at 10 mR had a standard deviation of 20 percent. Solid hot-pressed lithium fluoride dosimeters, a more recent innovation, were also tested and found to be as sensitive as glass-encapsulated dosimeters.

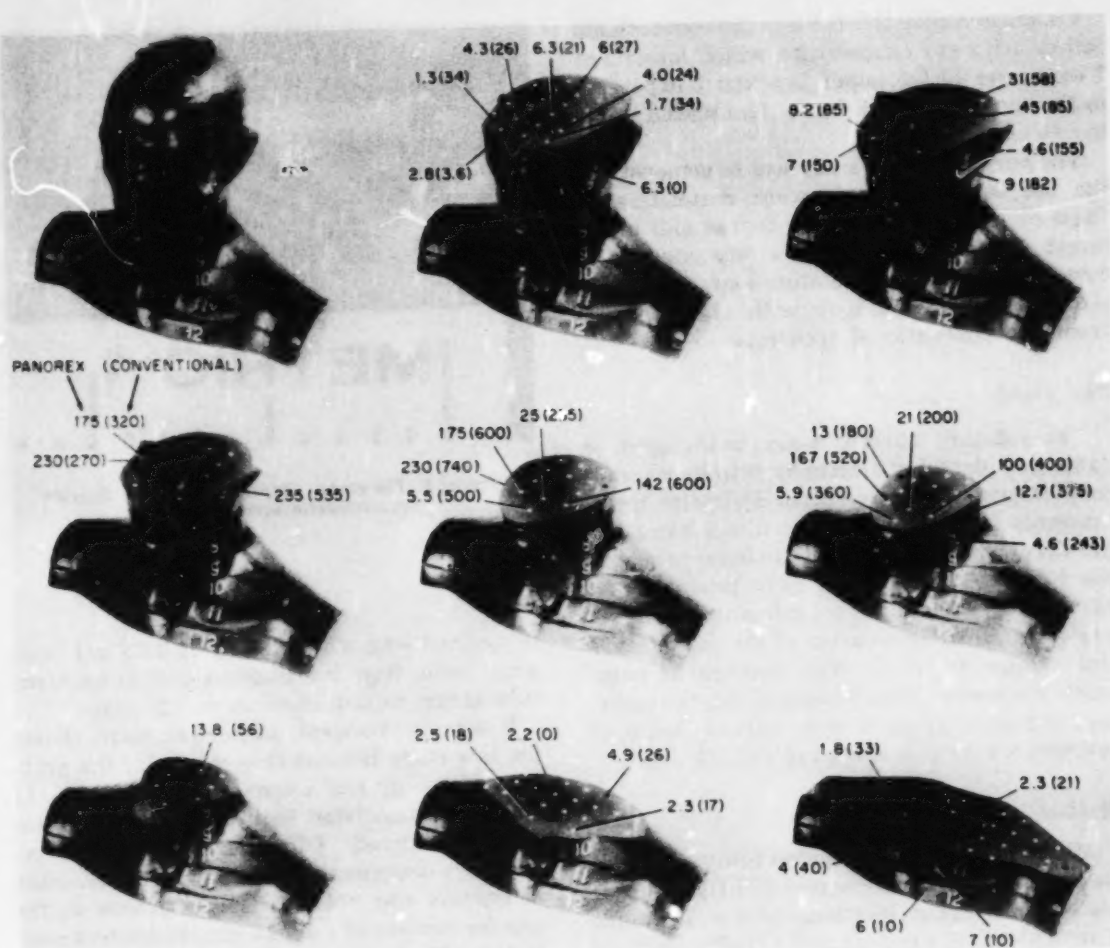


Figure 4. Milliroentgen exposure for a full mouth x-ray procedure with the Panorex vs. a conventional (values in parentheses) technique

Findings

Radiation dosimetry data for patients exposed to panoramic and conventional full-mouth radiographic procedures were obtained by exposing the glass-encapsulated TLD at various locations within a Rando human phantom. In order to obtain a reliable value for a single exposure from the Panorex, it was necessary to calculate this from ten integrated exposures.

A comparison of exposures at selected points of interest is illustrated in figure 4, in milliroentgens. Phantom sections 5 and 6 were in the center of the primary x-ray beam, 3 inches long by 0.25 inches wide. The exposure for a single Panorex procedure is shown first, followed by the exposure for a full-mouth, conventional x-ray procedure in parenthesis. The conventional procedure consisted of 14 intra-oral films with overlapping fields of exposure.

A Victoreen R meter was used to calibrate the TLD system in the energy range of interest. For this reason the exposure measurements in these experiments are reported in milliroentgens. Factors for the conversion of exposure to absorbed dose are available in NBS Handbook 85.

TLD measurements of surface exposures on the phantom were compared with film dosimeter measurements using the Panorex procedure and are shown in table 1. The TLD was considered to be the more accurate of the two dosimeters because it is less energy dependent than film. Kodak type 3 personal monitoring film was used in the study. TLD and film readings for sections 5 and 6 exposed to the primary beam are consistent. The readings in the other sections are outside the primary beam and are believed less consistent because of the limited accuracy of film as well as TLD in this low exposure range and the variable response of film to the spectrum of scattered radiation energies.

Table 1. Comparison of exposure values for thermoluminescent and film dosimetry for surface exposures of a Rando phantom

Phantom section	Location	TLD (mR)	Film (mR)
3	Right eye	2.6	2.0
4	Right eye	7.3	3.0
5	Right jaw	235	240
6	Right jaw	230	230
7	Right jaw	13.2	20.0
11	Parathyroid	4.0	.9
12	Thyroid	5.6	.6

Summary

The glass-encapsulated thermoluminescent dosimetry system has been found to be an effective method of conveniently measuring radiation exposure from dental and other diagnostic medical x-ray machines. It has been found to overcome some of the important problems associated with the use of small ion chambers and film.

The TLD system was compared with the film dosimetry and the results were consistent except at very low exposures where film suffers from energy dependence in a scattered radiation field.

It is apparent from the phantom measurements obtained that the patient radiation ex-

posure is considerably less from the panoramic radiographic procedure than from the conventional full-mouth series.

Acknowledgment

The authors are grateful to Mr. J. M. Brown, Jr., Radiation Safety Officer at the National Institutes of Health, for his counsel and support; to Mr. R. W. Swain of the National Cancer Institute for his advice and guidance; and to Dr. H. Swerdlow and Mr. H. Herman of the National Institute of Dental Research for their assistance.

Representative products and manufacturers are named for identification only, and listing does not imply endorsement by the Public Health Service and the U.S. Department of Health, Education, and Welfare.

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A Procedure for Evaluating Environmental Radiation Dose to Children in the Vicinity of the Hanford Project in Washington, April 1965–January 1967

John F. Honstead¹

The Hanford Atomic Energy Commission Installation in southeastern Washington releases small amounts of radioactive materials to the local environment in low-level waste effluents. Radioactive materials enter the Columbia River with reactor cooling water released after a short hold-up period. Once released to the river, this radioactive material enters a number of ecological pathways of varying complexity which may result ultimately in some of the radioactivity reaching human populations living adjacent to the Hanford project. The radiation dose received by populations affected by Hanford operations is evaluated annually (1). Part of the dose such people receive is the result of internal deposition of radionuclides obtained from locally produced foodstuffs. The necessary information for estimating such deposition is the concentration of radionuclides in locally-produced foodstuffs, the consumption levels of such foods by local people, and the metabolic behavior of the radionuclides when consumed.

A conventional environmental program such as that followed at Hanford for many years will adequately provide information concerning the average concentration of radionuclides in locally-produced foodstuffs and the distribution of nuclide concentrations about the sample mean (1). Likewise, the literature *e.g.*, the ICRP Report of Committee II on Permissible Dose for Internal Radiation (2), provides information concerning the uptake and retention of most radionuclides of interest when consumed by man. In the absence of any more definitive information concerning absorption of nuclides from specific foodstuffs these data are utilized in our dose estimates.

¹Mr. Honstead is manager, Environmental Studies Section, Pacific Northwest Laboratory, Battelle Memorial Institute, Richland, Wash. 99352.

The middle step in this calculation process (the estimation of consumption levels and the population distribution of various consumption levels) is actively being studied by Battelle-Northwest Laboratory. To obtain dietary data for a sample of the adult population, a diet form was prepared which is routinely presented to all people measured in the Hanford whole-body counters. The questionnaire requires a subjective estimate of consumption levels of various significant foodstuffs on the part of the subject. For example, he is asked to estimate "how many glasses of water usually drunk per day." Similar questions are also asked regarding consumption of milk, seafood, game birds, Columbia River fish, and fresh meat. Supporting information concerning sources of such foodstuffs is obtained to help identify the size of the population routinely consuming certain kinds of foods from local sources. An initial report of this investigation was recently issued (3).

The Hanford whole-body counter is used routinely as a monitoring tool in the plant; thus, the vast majority of the people measured are plant employees. These employees are assumed to be a representative sample of the local adult population but they obviously cannot be representative of the entire population. The major population group missing from this survey is children living near the Hanford facilities. The dietary habits of children are vastly different from those of adults and cannot really be derived from adult data. To study the children's dietary levels we have initiated an investigation in cooperation with the local school system. This paper describes the program that was developed and presents some of the results obtained to date.

Description of the procedure

In establishing a research procedure to investigate diets and radionuclide body burdens in local children we had to provide motivation for the schools to cooperate with us, for the parents to give permission for their children's participation, and for the children to take part in the study. A serious attempt was made to inform the children about radioactivity and radiation along with the introduction of the program. Questions that arose were answered frankly and information concerning the measurements and the results were made available to anyone interested. More than 80 percent of the 1,800 school children in the eight elementary schools (grades 1-6) so far approached participated in this study.

Questions requiring evaluation by the child of the amounts of various foodstuffs consumed cannot reliably determine consumption levels for children. Instead the child is asked to keep a record of the pertinent foodstuffs eaten and drunk during a consecutive 7-day period. This record is maintained by recording each helping or cup of foodstuff consumed. Some diet records, perhaps between 1 and 2 percent, were discarded because the child obviously did not understand what was required.

About 2 weeks after the classroom discussion the Hanford mobile whole-body counter was moved to the school and parked in a convenient location on the schoolground. The counter uses a shadow shield and incorporates an 11-inch sodium iodide crystal (4, 5). It requires about 1 month to count the children in one elementary school. Each child is counted for 10 minutes in the shadow shield counter and about 2 minutes are required for printing and recording the data. Thus, it is possible to measure 25 to 30 children each day. Each child is absent from class about 30 minutes.

Diet study results

The data obtained from diet record forms are reduced to punch cards for use in an electronic computer system and will ultimately be entered on a magnetic tape file. To date a little over 1,500 such records have been analyzed and more than twice that number have been collected from school children. Some of the

consumption level distributions assembled by electronic data processing techniques are shown in figures 1 through 4.

Figure 1 shows the water consumption reported by children. Older children averaged slightly higher water consumption than the younger children, although the difference is probably not significant. When adults estimated their own water consumption levels they reflected a significant bias for even numbers and multiples of 5. The children's results, being a tabulation of actual consumption observations, do not have this kind of bias.

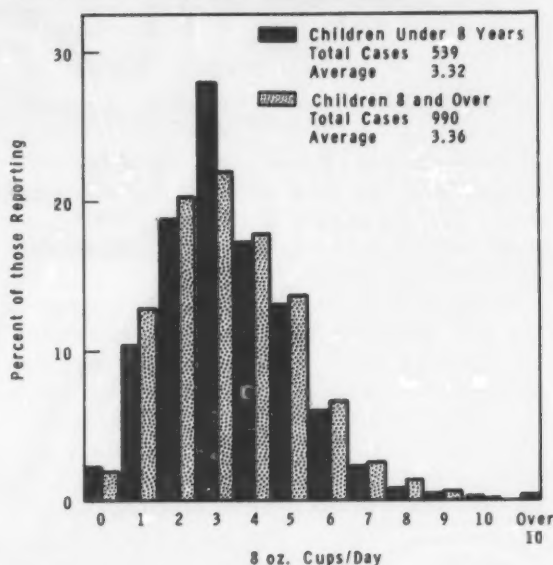


Figure 1. Water consumption during a 7-day recording period

Figure 2 shows milk consumption as reported by children. The children averaged about 2.7 cups of milk per day compared to an adult average of 1.7 cups per day.

Figure 3 shows the children's estimates of their seafood consumption. The study attempted to obtain estimates of the number of times per year that they ate seafood produced along the Washington coast, such as fresh oysters, fresh clams and fresh crab meat. This chart does not represent actual consumption data but the children's estimates of their annual consumption levels. The bias introduced by human preference for certain numbers can be noted. The children estimated an average consumption

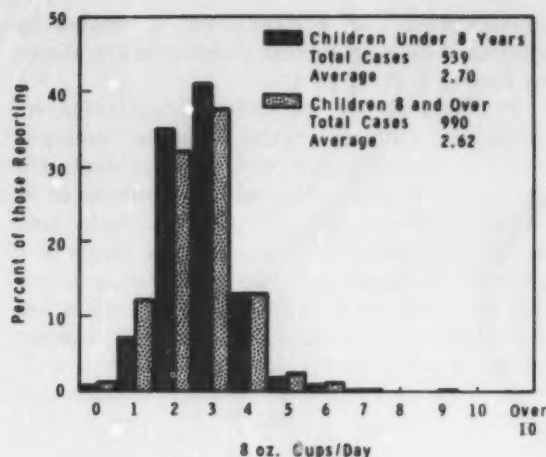


Figure 2. Milk consumption reported by elementary school children

of local seafood of about 2.8 meals per year compared to the adult estimate of 6 meals per year. Over 60 percent of the children reported never eating local seafood compared to only 35 percent of adults.

In figure 4 the consumption level distribution for fish caught in the Columbia River below the Hanford plant is shown. Children under 8 report an average of 2.4 meals per year while the older children report an average of 2.7 meals per year. This probably reflects a mistaken interpretation of the question on the part of the children. They probably are in-

cluding all fish consumption, in some cases, rather than limiting it to Columbia River fish. Adults, when asked the same question, estimated 1.9 meals per year. Seventy-five percent of the adults indicated that they never eat Columbia River fish.

Whole-body counter measurements

None of the more than 3,000 children measured in the mobile whole-body counter to date have had body burdens of radionuclides outside of the range anticipated on the basis of known environmental conditions. Typical values of radionuclide burdens measured in children were 3 to 5 nCi of each of the radionuclides, zinc-65, sodium-24 and cesium-137. Body burdens ranging up to several times the typical values were occasionally detected where unusual circumstances resulted in diet sources more directly related to the Columbia River. These ranges agree with those that would be predicted from our knowledge of the environmental concentration levels. The quantitative measurement of radionuclides in children depends on the construction of a suitable calibration function for the shadow shield counter. It cannot be assumed that the calibration factors derived for standard man are applicable to children's measurements. A calibration study was conducted concurrently with the measurement of children. In the absence of a definition

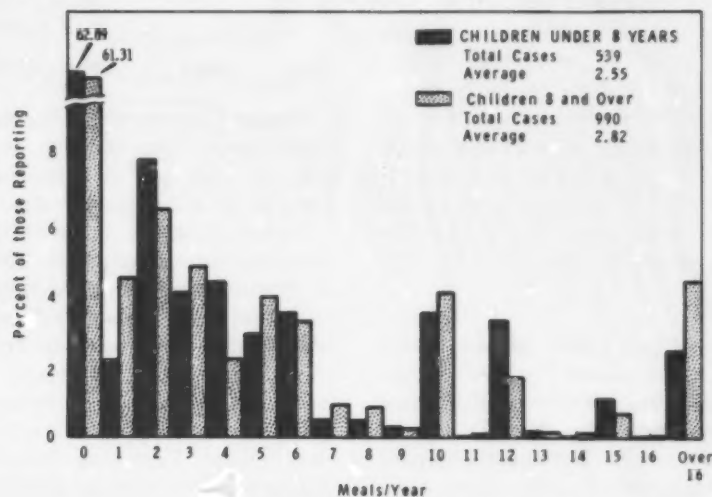


Figure 3. Consumption levels for locally produced seafood

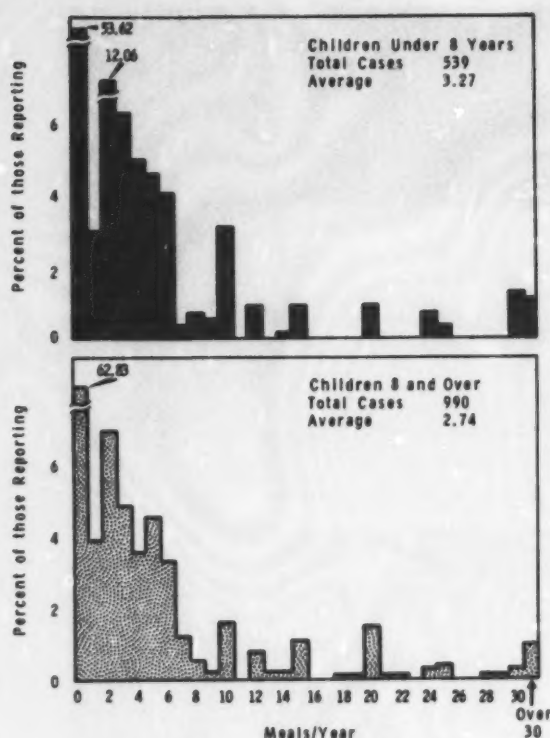


Figure 4. Columbia River fish consumption reported by Richland school children

for a standard child we developed an array of 9 phantoms for children ranging in size from 48 to 107 pounds. The phantoms are constructed of 1-pound boxes of sugar as shown in figure 5. A phantom containing no added radioactivity is first constructed on the bed of the counter and measured to provide background data. Then a phantom using sugar boxes containing known amounts of radionuclides is constructed in an identical way and measured with the counter. After subtracting background readings the measurements may be used to calculate a calibration factor for the radionuclides and phantom size used. In this way, calibration factors for each of the 9 phantoms for zinc-65, potassium-40, cesium-137, and sodium-24 were derived.

These data were used to construct an empirical function relating body size to calibration factor which can be programmed for the

computer to provide absolute body burden measurements. Linear, exponential and power functions were examined for these data. The goodness of fit of functions obtained with a parameter of pounds weight per inch of height as compared to functions involving simply pounds was also evaluated. A linear correlation technique was used for selecting the best fit for each of these functions. The calibration curves that best fit the data were exponential functions calculated in this way and the calibration points from which the functions were derived. It would be most helpful if some calibration data from children were available to confirm these calibration functions.

Application of the procedure

Environmental dose estimates for the population living adjacent to the Hanford plant include the dose to a typical resident and to a special population group having diet habits that maximize exposure. The procedure described for obtaining data from school children will assist with the identification and study of the affected population

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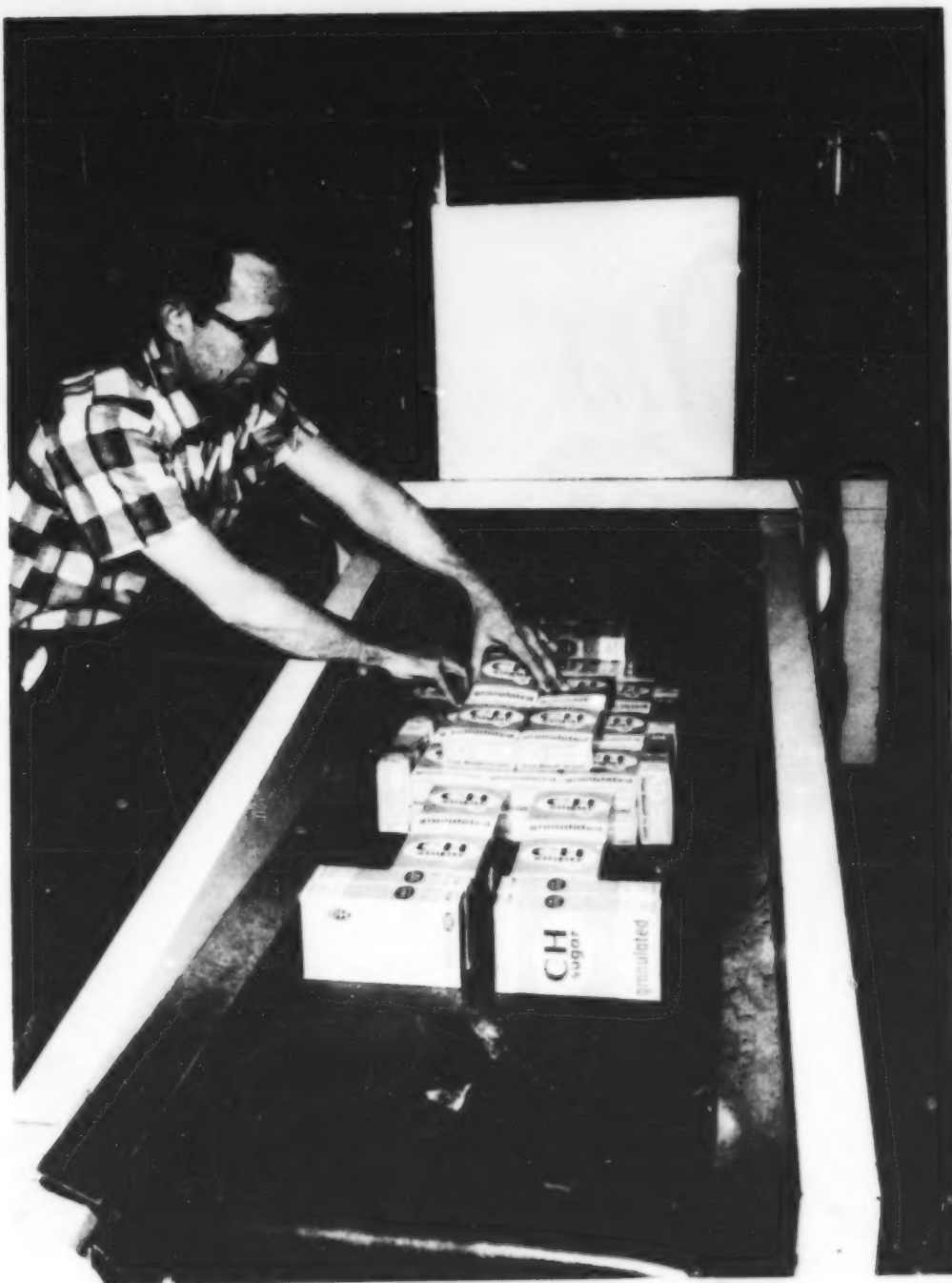


Figure 5. Shadow-shield whole body counter with phantom in place

Gamma-Emitting Fallout in Surface Air at Fort Collins, Colo., 1962-1967¹

Daniel W. Wilson and Gerald M. Ward²

Surface air gamma-ray activities of the fission products cerium-144, antimony-125, ruthenium-106, cesium-137 and a neutron activation product, manganese-54, all from nuclear weapons testing, were measured at Fort Collins, Colo. from 1962 to 1967. These measurements were part of a study of the transport of worldwide fallout from the atmosphere to milk. Of these radionuclides, only cesium-137 has been observed regularly in milk (1), but there has been some evidence of manganese-54 in milk (2). All of these radionuclides (with the addition of zirconium-niobium-95) have been identified in air, precipitation and forages, and cerium-144, cesium-137 and manganese-54 have been identified in animal tissue (2). In periods immediately following nuclear weapons tests, iodine-131 and barium-lanthanum-140 were observed in forage and milk (3).

In our studies, air levels of cesium-137 have been found to be a reliable indication of forage and milk contamination, and we believe that the importance of direct deposition from air to vegetation (dry deposition) has been underestimated previously in food chain transport models (4). Measurements of radionuclides other than cesium-137 are valuable because the data provide a means of interpreting the atmospheric behavior of fallout.

Analytical methods

Sampling was performed by drawing air through particulate (BM-40) filter pads using a high volume sampler with a flow rate of one SCM per minute. The sampler was located 1.5 meters above ground in a louvered box used to exclude rain. Air was sampled each day from noon to 4 p.m. The volume flow rate of the sampler was read with a calibrated meter at the beginning and end of each sampling period. Pads were usually collected for gamma-

ray analysis on a weekly basis, but daily during the summer months of high fallout.

Counting was carried out by gamma-ray scintillation spectrometry with a 4- by 8-inch NaI (Tl) crystal and a multichannel pulse height analyzer. Determination of activity of each radionuclide was accomplished by computerized spectrum stripping of interference from the photopeak areas. The same computer program corrected for radioactive decay from day of counting to the day of sampling. Cesium-137, with a long radioactive half-life, was redetermined after a time lapse sufficient to allow interfering radioactivity to decay to an insignificant amount. It is expected that for this reason cesium-137 measurements are the most reliable of the nuclides reported.

Results and discussion

Monthly means for each fission product were characterized by rather high standard deviations, but the time trends for all radionuclides were generally similar (table 1 and figure 1). High standard deviations are attributed to actual fluctuations in surface air activities during a month rather than to experimental errors, as monthly mean values compare well with other data published for the same time period (5, 6). Peak values for all radionuclide activities in air during the 5-year time span occurred in the spring of 1963, and levels decreased approximately exponentially from that time. The exponential decrease was modified by two factors, a "spring maximum" each year, and by increases in activities in 1966 following foreign atmospheric nuclear tests.

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² Dr. Wilson and Dr. Ward are from the Department of Animal Science, Colorado State University, Fort Collins, Colo. 80521.

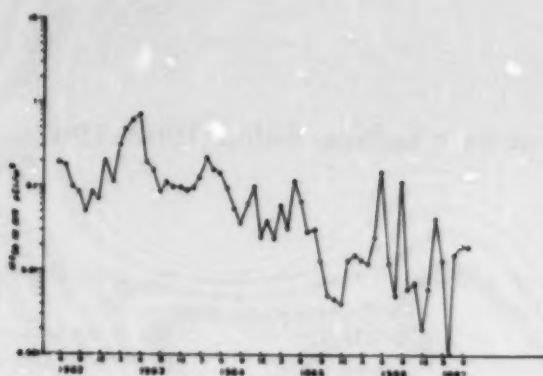


Figure 1. Gamma emitting fallout radionuclide in surface air (antimony-125)

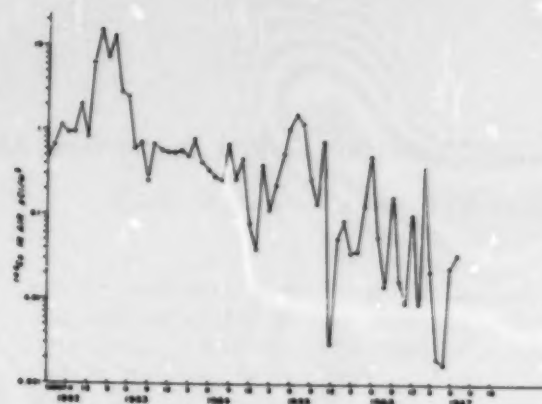


Figure 1. Gamma emitting fallout radionuclide in surface air—Continued (cerium-144)

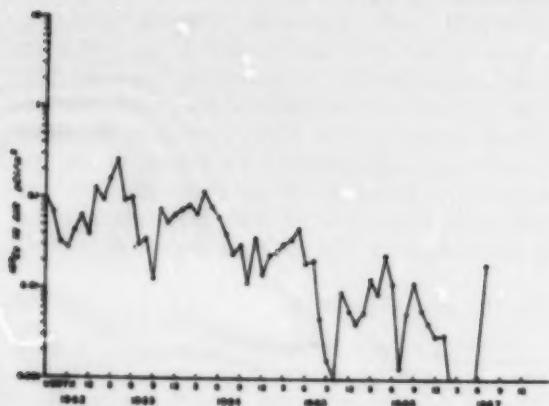


Figure 1. Gamma emitting fallout radionuclide in surface air—Continued (cesium-137)

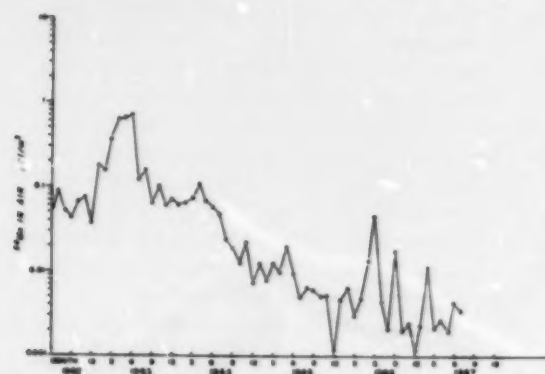


Figure 1. Gamma emitting fallout radionuclide in surface air—Continued (manganese-54)

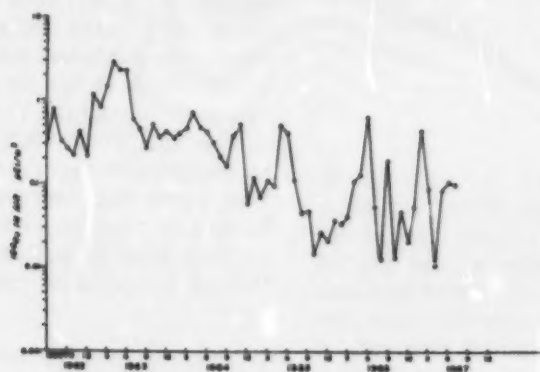


Figure 1. Gamma emitting fallout radionuclide in surface air—Continued (ruthenium-106)

Table 1. Antimony-125 in surface air at Fort Collins, Colo.
(pCi/m³)

Month	1962		1963		1964		1965		1966		1967	
	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
January			0.196	0.352 (9)	0.087	0.043 (8)	0.038	0.019 (3)	0.014	0.009 (2)	0.006	0.006 (4)
February			.114	.082 (12)	.084	.023 (5)	.023	.019 (4)	.015	.010 (8)	.041	.055 (2)
March			.295	.182 (10)	.128	.018 (5)	.056	.024 (2)	.013	.008 (3)	.014	.011 (1)
April			.466	.384 (8)	.269	.089 (1)	.080	.014 (2)	.013	.006 (7)	.001	.001 (1)
May			.597	.422 (8)	.149	.091 (6)	.110	.100 (2)	.034	.023 (12)	.018	.011 (1)
June			.695	.438 (8)	.142	.087 (22)	.063	.080 (3)	.137	.379 (13)	.019	.023 (10)
July	0.197	0.174 (2)*	.189	.130 (7)	.080	.085 (22)	.028	.031 (7)	.012	.010 (7)	.019	.005 (10)
August	.173	.061 (13)	.153	.011 (1)	.053	.034 (10)	.090	.018 (5)	.006	.004 (10)		
September	.100	.034 (17)	.063	.017 (4)	.035	.008 (3)	.015	.011 (3)	.106	.278 (8)		
October	.085	.079 (11)	.114	.011 (1)	.081	.049 (3)	.005	.011 (1)	.006	.006 (9)		
November	.051	.046 (9)	.095	.030 (4)	.062	.049 (5)	.005	.011 (1)	.006	.005 (4)		
December	.089	.038 (8)	.064	.003 (4)	.024	.018 (4)	.066		.002	.001 (1)		

* Parentheses give number of samples.

Table 1. Cerium-144 in surface air at Fort Collins, Colo.
(pCi/m³)

Month	1962		1963		1964		1965		1966		1967	
	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
January			6.02	7.38 (9)	0.531	0.273 (6)	0.038	(1)	0.049	0.052 (2)	0.010	0.010 (4)
February			13.9	10.3 (12)	.555	.096 (5)	.364	0.315 (2)	.083	.036 (7)	.225	.011 (1)
March			7.02	4.87 (10)	.482	.017 (5)	.111	.002 (2)	.035	.038 (8)	.021	.011 (1)
April			13.0	6.79 (8)	.756	(1)	.229	.124 (2)	.037	.025 (6)	.002	.011 (1)
May			2.75	1.96 (6)	.405	.146 (6)	.569	.423 (3)	.123	.166 (8)	.002	.011 (1)
June			2.41	1.57 (6)	.351	.108 (22)	.071	(1)	.518	1.33 (13)	.024	.029 (7)
July	0.495	0.603 (2)*	.599	.486 (7)	.278	.239 (21)	1.44	.970 (14)	.055	.019 (4)	.037	.037 (10)
August	.683	.407 (10)	.594	.094 (1)	.245	.166 (9)	1.15	.758 (9)	.014	.009 (10)		
September	1.12	1.50 (14)	.244	.144 (4)	.645	.486 (3)	.252	.045 (2)	.155	.399 (13)		
October	.931	1.10 (10)	.568	(1)	.254	.323 (3)	.133	.086 (2)	.016	.017 (7)		
November	.945	.296 (9)	.551	.134 (4)	.481	.488 (5)	.660	(1)	.000	.007 (4)		
December	1.90	.828 (8)	.534	.098 (4)	.078	.044 (4)	.003	(1)	.084	.001 (1)		

* Parentheses give number of samples.

Table 1. Cesium-137 in surface air at Fort Collins, Colo.
(pCi/m³)

Month	1962		1963		1964		1965		1966		1967	
	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
January			0.124	0.208 (9)	0.070	0.038 (6)	0.022	0.002 (3)	0.004	0.001 (2)	0.003	0.004 (2)
February			.092	.043 (11)	.079	.016 (5)	.025	.007 (4)	.005	.004 (8)	.001	.001 (2)
March			.155	.086 (10)	.065	.016 (5)	.029	.002 (2)	.012	.005 (8)	.000	.000 (1)
April			.255	.306 (6)	.113	(1)	.034	.015 (2)	.009	.006 (7)	.000	.000 (1)
May			.094	.081 (8)	.078	.036 (6)	.044	.027 (2)	.023	.030 (11)	.000	.000 (1)
June			.098	.033 (4)	.060	.029 (23)	.119	.019 (4)	.011	.012 (7)	.001	.003 (4)
July	0.096	(1)*	.031	.019 (7)	.039	.043 (19)	.119	.020 (7)	.001	.002 (4)	.018	.096 (2)
August	.068	.045 (13)	.033	(1)	.023	.019 (10)	.005	.005 (4)	.005	.004 (5)		
September	.032	.016 (17)	.013	.004 (4)	.028	.012 (3)	.002	.002 (2)	.011	.010 (11)		
October	.028	.019 (11)	.071	(1)	.011	.001 (2)	.001	(1)	.006	.007 (8)		
November	.042	.013 (9)	.051	.011 (4)	.034	.050 (3)	.009	(1)	.004	.003 (3)		
December	.063	.039 (8)	.065	.005 (4)	.014	.010 (4)	.006	(1)	.003	.001 (1)		

* Parentheses give number of samples.

Table 1. Manganese-54 in surface air at Fort Collins, Colo.
(pCi/m³)

Month	1962		1963		1964		1965		1966		1967	
	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
January			0.173	0.266 (8)	0.090	0.036 (6)	0.012	0.005 (3)	0.005	0.004 (2)	0.002	0.002 (4)
February			.154	.094 (9)	.063	.011 (5)	.008	.006 (4)	.006	.004 (7)	.011	.014 (2)
March			.356	.183 (10)	.071	.008 (5)	.012	.005 (2)	.003	.003 (8)	.002	.001 (1)
April			.614	.532 (6)	.104	.034 (1)	.010	.001 (2)	.005	.004 (6)	.003	.001 (1)
May			.630	.483 (8)	.067	.034 (6)	.019	.014 (4)	.013	.016 (10)	.002	.001 (1)
June	0.056	0.045 (2)*	.683	.392 (6)	.056	.021 (22)	.009	.005 (3)	.043	.124 (13)	.004	.006 (7)
July	.088	.049 (13)	.120	.110 (7)	.047	.060 (21)	.005	.005 (2)	.004	.004 (6)	.003	.003 (9)
August	.061	.028 (16)	.143	.051 (1)	.023	.011 (10)	.006	.008 (5)	.002	.002 (7)		
September	.043	.026 (11)	.063	.005 (4)	.018	.003 (3)	.005	.005 (2)	.017	.055 (13)		
October	.067	.027 (9)	.098	.051 (1)	.012	.013 (3)	.005	.005 (1)	.002	.002 (9)		
November	.073	.041 (7)	.059	.027 (4)	.022	.013 (5)	.005	.005 (1)	.002	.002 (4)		
December	.038	.022 (3)	.069	.005 (4)	.007	.004 (3)	.001	.001 (1)	.001	.001 (1)		

* Parentheses give number of samples.

Table 1. Ruthenium-106 in surface air at Fort Collins, Colo.
(pCi/m³)

Month	1962		1963		1964		1965		1966		1967	
	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
January			1.10	1.63 (9)	0.345	0.189 (6)	0.113	0.050 (3)	0.035	0.024 (2)	0.051	0.042 (4)
February			.808	.497 (9)	.381	.073 (5)	.067	.050 (4)	.033	.018 (8)	.406	.562 (3)
March			1.42	.903 (10)	.442	.027 (5)	.104	.014 (2)	.039	.009 (8)	.082	.001 (1)
April			2.74	1.91 (6)	.678	.061 (1)	.061	.050 (2)	.102	.200 (7)	.010	.010 (1)
May			2.23	1.61 (6)	.441	.199 (6)	.458	.654 (4)	.122	.194 (11)	.082	.001 (1)
June	0.337	0.266 (2)*	2.18	1.10 (6)	.394	.175 (2)	.381	.325 (4)	.580	1.04 (13)	.100	.090 (10)
July	.774	.502 (13)	.563	.363 (7)	.293	.296 (3)	.107	.064 (12)	.052	.062 (7)	.092	.039 (10)
August	.334	.211 (16)	.439	.051 (1)	.203	.083 (10)	.044	.026 (8)	.012	.008 (11)		
September	.261	.078 (9)	.261	.056 (4)	.159	.045 (3)	.046	.029 (2)	.181	.560 (11)		
October	.214	.151 (9)	.482	.051 (1)	.355	.474 (3)	.014	.013 (1)	.013	.011 (9)		
November	.434	.294 (7)	.327	.064 (4)	.483	.244 (5)	.025	.015 (1)	.045	.046 (4)		
December	.211	.151 (3)	.401	.054 (4)	.055	.055 (4)	.020	.020 (1)	.020	.020 (1)		

* Parentheses give number of samples.

The spring maximum effect, which is connected to a periodicity in the stratospheric tapping rate (7), was most pronounced for cesium-137, as was also observed by Gustafson (6). Damping of the spring maximum effect for the shorter-lived radionuclides may have been due in part to the more rapid losses due to radioactive decay. There was also a difference between the apparent stratospheric residence times for cesium-137 and the shorter-lived nuclides. Stratospheric residence time was estimated by the least squares fit of radionuclide levels verses time according to the equation $A = A_0 e^{-\lambda_a t}$, where λ_a , the observed decay rate, represents the sum of $\lambda_a + \lambda_r$, the atmospheric and radioactive decay rates, respectively. Correction for radioactive decay back to the time of the last major atmospheric tests in 1962 and treatment of these data by log-linear regression analysis led to anomalous stratospheric residence times for the short-lived radionuclides (table 2). In this

procedure, the slope of the regression line represents the hypothetical rate constant for stratospheric tapping. It is evident that the behavior is more complex than indicated by this procedure, probably due to large direct contributions of the 1962 atmospheric tests to tropospheric levels and to the more recent fallout following the foreign atmospheric nuclear tests.

Table 2. Atmospheric residence times of fallout radionuclides

Radionuclide	Observed Half-time * and Standard deviation (days)	Radioactive Half-time * (days)	Atmospheric Half-time * (days)
Cesium-144	250 ± 50	285	2,300
Antimony-125	400 ± 70	780	680
Ruthenium-106	380 ± 65	365	7,100 (increasing)
Cesium-137	400 ± 60	~11,000	410
Manganese-54	300 ± 40	312	2,000

* Half-times derived from statistically best fit of each set of data to the function:

$A = A_0 e^{-\lambda_a t}$, where λ_a , the observed decay rate, represents the sum of $\lambda_a + \lambda_r$, the atmospheric and radioactive decay rates, respectively.

^b Calculated as described.

The well-defined behavior of cesium-137 in tropospheric air provides a basis for using air activities as a parameter in considerations of the fallout rate to the biosphere. Monthly cesium-137 activities were analyzed into two components, one describing the buildup of surface air levels which occurred each year to a spring peak, and another describing the decrease of air levels through the spring and summer. The mean half-time for the buildup was 80 days, while the mean exponential half-time for depletion during the summer was 45 days. The 5-year decline in surface air levels, indicated by a line drawn through the annual peak values (figure 2), occurred with a 300-day half-time. This latter component describes the stratospheric residence half-time of cesium-137. While the mechanisms of atmospheric transport of fallout are complex, these data indicate that surface air levels from worldwide fallout are characterized by well defined

patterns. This behavior will be useful for prediction of fallout in surface air and subsequent biospheric contamination in the event of further nuclear releases in the atmosphere.

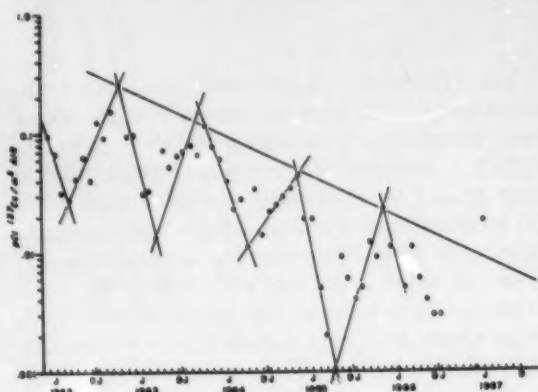


Figure 2. Analysis of cesium-137 in surface air

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Cesium-137 in Milk From the Colorado State University Dairy Herd, 1962-1967¹

Anthony F. Gallegos and Gerald M. Ward²

The University dairy herd consists of approximately 125 high milk-producing cows of four breeds, but principally Holstein. The results for transfer of cesium-137 from feed to milk should be applicable to commercial dairy farm operations. Feed and fallout intake along with milk production records and cesium-137 levels of milk were available from this large herd and were used to compare to the relationships developed from closely controlled feeding experiments with smaller numbers of cows (1).

Milk samples were obtained throughout the year from the composite milk output of the entire herd by sampling the bulk storage tank at the dairy farm. Milk from small sub-herds of ten to twenty cows which are grazing on pasture or fed green-cut alfalfa was available during summer months. Bulk milk samples contained milk from these sub-herds at times, but the volume of milk from the latter sources was not sufficient to significantly influence cesium-137 levels in the pooled milk. The main dairy herd was dry-lot fed the year-round. Feed consisted of stored alfalfa hay (principally the third cutting), mixed grain and corn silage. The feeding program is fairly typical of Colorado or western dairy herds.

Analysis for cesium-137 and potassium-40 was done by counting 5.4 liters in a Marinelli-type beaker placed on a 4- by 8-inch NaI (TI) crystal. Details in milk analysis have been described previously (2).

Results

The concentration of cesium-137 in milk (pCi/liter) increased through 1962 and reached a peak in the summer of 1963. Data plotted in figure 1 and tabulated in table 1 consists

of monthly means with standard deviations. Samples were collected more frequently in the summer months because more variability was expected. Standard deviations were a small percent of the means in the first and last quarter of the years (winter feeding period), but variability increased each summer. This was due to numerous changes in hay during the summer. Third-cutting hay was largely fed in the winter but the supply generally ran out in June or July. Thus between that time and the time when another supply of third-cutting hay was available, first or second cutting was fed. We have shown large differences in the cesium-137 content of hay for the three cuttings (3). The variation in milk from cows on pasture or fed green-cut alfalfa corresponded generally with seasonal trends in the direct fallout rate. This relation, however, was obscured at times by feeding supplemental hay which contained more cesium-137 than the fresh forage being consumed. Thus direct comparisons cannot be made between air or rainfall samples and milk. That these variations were not due to analytical variation is supported by the observation that no such trends were observed in the potassium content of milk (4). Potassium and cesium-137 were determined on the same samples and by the same method; gamma-ray spectrometry.

The relationship between the bulk tank levels of cesium-137 versus day collected for the period after the peak gave a linear regression coefficient equivalent to a half-time of 467 days (S.D. ± 22). This is similar to the half-time found for cesium-137 activity in air, which was 400 days (S.D. ± 59). Both cesium-137 in air and milk show periodic deviations from their respective regression lines. For air, this is related to the spring maximum effect, but for milk it is related to feeding practices which may change at any time within the year.

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² Mr. Gallegos and Dr. Ward are with the Department of Animal Science, Colorado State University, Fort Collins, Colo. 80521

Table 1. Bulk and pasture milk, cesium-137 monthly averages (pCi/liter)

Month	Type	1962		1963		1964	
		Mean	S. D.	Mean	S. D.	Mean	S. D.
January	Pasture			30.4	2.0 (8)	82.5	11.3 (4)
	Bulk						
February	Pasture			30.5	2.1 (8)	85.9	3.6 (4)
	Bulk						
March	Pasture			29.6	6.3 (5)	93.5	6.8 (4)
	Bulk						
April	Pasture	20.0	(1) *	35.9	3.9 (9)	76.7	2.3 (3)
	Bulk						
May	Pasture	63.8	36.7(18)	59.9	33.5(18)	57.9	19.3(14)
	Bulk	13.9	12.5 (6)	31.9	5.0(11)	79.0	26.9 (2)
June	Pasture	75.1	18.4(18)	158.3	29.6(15)	136.9	42.3(21)
	Bulk	28.1	23.3(13)	48.9	17.5(12)	77.2	16.5 (6)
July	Pasture	103.6	50.9(15)	112.6	22.7(13)	74.3	22.1(19)
	Bulk	60.4	24.8(14)	71.4	16.0(10)	101.4	7.1 (2)
August	Pasture	62.0	13.8(20)	118.2	19.7(11)	106.2	1.2 (2)
	Bulk	39.2	21.9(16)	103.1	19.0(11)		
September	Pasture	67.8	18.8(11)	101.2	16.1(20)	63.9	2.2 (2)
	Bulk	41.5	34.3(10)	138.5	23.4 (5)		
October	Pasture	36.5	8.3 (5)	85.6	— (1)	63.7	6.2 (2)
	Bulk	28.9	6.9 (3)	95.9	4.0 (5)		
November	Pasture	33.1	13.4 (4)	96.4	9.5 (5)	54.0	1.68 (4)
	Bulk	28.0	10.7 (4)				
December	Pasture			107.4	23.5 (3)	52.2	3.03 (3)
	Bulk	30.1	2.6 (4)				

Month	Type	1965		1966		1967	
		Mean	S. D.	Mean	S. D.	Mean	S. D.
January	Pasture			40.1	1.4 (6)	25.9	22.6 (2)
	Bulk	51.3	3.1 (5)				
February	Pasture			38.2	1.1 (6)	13.5	1.0 (2)
	Bulk	64.1	9.7 (5)				
March	Pasture			34.5	3.5 (7)	21.6	(1)
	Bulk	70.3	5.4 (4)				
April	Pasture			33.4	2.1 (8)		
	Bulk	55.9	9.3 (5)				
May	Pasture			31.9	2.1 (6)		
	Bulk	88.4	23.9(10)				
June	Pasture			34.1	4.7 (3)	15.5	2.0 (3)
	Bulk	54.2	4.7 (4)				
July	Pasture			29.1	3.2 (7)	15.7	3.6 (5)
	Bulk	77.6	9.4(30)				
August	Pasture			29.0	5.2(18)	15.3	4.0 (7)
	Bulk	59.8	3.3 (2)				
September	Pasture			29.2	1.0 (2)		
	Bulk	61.9	26.5(27)				
October	Pasture			14.2	1.0 (2)		
	Bulk	21.3	5.3 (2)				
November	Pasture			19.4	4.1 (5)		
	Bulk	18.2	9.1(16)				
December	Pasture			19.8	1.0 (2)		
	Bulk	18.1	7.2 (2)				

* Numbers in parentheses indicate the number of samples.

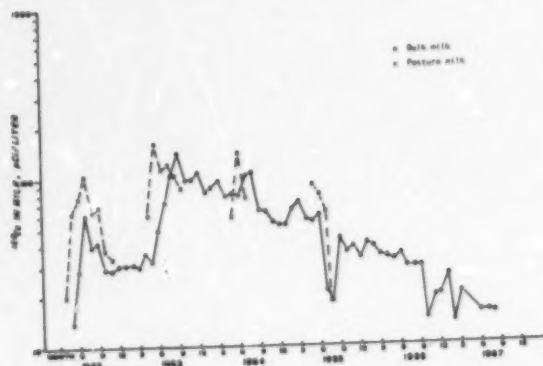


Figure 1. Cesium-137 in milk

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SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Federal and State agencies are involved in efforts to monitor continuously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained through radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Fresh milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, fresh milk is the single food item most often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of fresh milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (1-3). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is

a need to initiate careful evaluation of exposure (3). Additional guidelines are provided by the FRC Protective Action Guides (4) and by the International Commission on Radiological Protection (5, 6).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organiza-

tions routinely monitor radionuclide levels in milk.

1. Pasteurized Milk Network April 1968

National Center for Radiological Health and
National Center for Urban and
Industrial Health, PHS

The Public Health Service's Pasteurized Milk Network (PMN) is designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, Washington, D.C., the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN

appeared in the January 1968 issue of *Radiological Health Data and Reports* (1). Reference should also be made to the February 1968 issue (2), in which several changes in the interpretation and reporting of data were introduced.

Table 1. Analytical errors associated with determinations of radionuclide concentrations in a milk sample

Nuclide	Concentration (pCi/liter)	Error * (pCi/liter)	Concentration (pCi/liter)	Error * (percent of concentration)
Strontium-89	<50	5	≥50	10
Strontium-90	<20	2	≥20	10
Iodine-131	<100	10	≥100	10
Cesium-137	<100	10	≥100	10
Barium-140	<100	10	≥100	20

* Two standard deviations.

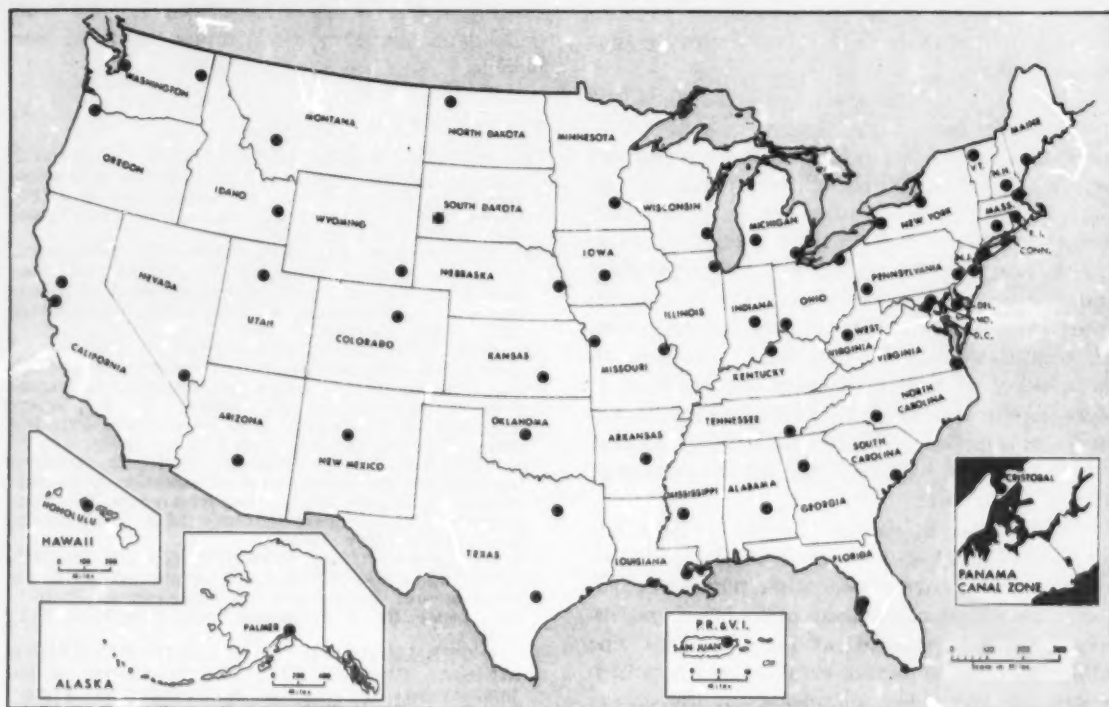


Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentrations of radionuclides in pasteurized milk for April 1968 and the 12-month period, May 1967 through April 1968 *

Sample location		Radionuclide concentration (pCi/liter)									
		Strontium-90		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		May 1967-April 1968	April 1968	May 1967-April 1968	April 1968	May 1967-April 1968	April 1968	May 1967-April 1968	April 1968	May 1967-April 1968	April 1968
Ala:	Montgomery	0	0	9	8	0	0	13	9	0	0
Alaska:	Palmer	0	0	6	5	0	0	17	13	0	0
Aris:	Phoenix	0	0	1	4	0	0	2	0	0	0
Arl:	Little Rock	0	0	21	18	0	0	19	19	0	0
Calif:	Sacramento	1	0	3	3	0	0	6	8	1	0
	San Francisco	1	0	3	5	0	0	3	2	0	0
C. Z:	Cristobal	0	0	2	0	0	0	14	3	0	0
Colo:	Denver	1	NA	5	0	1	0	7	7	0	0
Conn:	Hartford	NA	NA	9	10	0	0	14	5	0	0
Del:	Wilmington	NA	NA	11	11	0	0	9	4	0	0
D. C:	Washington	0	0	10	10	0	0	6	1	0	0
Fla:	Tampa	0	0	8	6	0	0	71	61	0	0
Ga:	Atlanta	0	0	15	17	0	0	22	19	0	0
Hawaii:	Honolulu	0	0	3	4	1	0	5	5	0	2
Idaho:	Idaho Falls	1	0	6	5	0	0	8	15	0	0
Ill:	Chicago	0	0	9	11	0	0	11	11	0	0
Ind:	Indianapolis	NA	NA	8	7	0	0	8	10	0	0
Iowa:	Des Moines	1	0	7	7	0	0	7	8	0	0
Kans:	Wichita	1	0	9	11	0	0	4	9	0	2
Ky:	Louisville	0	0	12	22	0	0	6	5	0	0
La:	New Orleans	0	0	23	24	0	0	25	31	0	0
Maine:	Portland	NA	NA	11	11	0	0	32	29	0	0
Md:	Baltimore	0	0	10	11	0	0	6	2	0	0
Mass:	Boston	0	0	12	14	0	0	26	19	0	0
Mich:	Detroit	NA	NA	8	8	0	0	12	10	0	0
	Grand Rapids	1	0	10	8	0	0	16	15	0	0
Minn:	Minneapolis	1	0	12	11	0	0	13	11	0	0
Miss:	Jackson	0	0	18	19	0	0	15	17	0	0
Mo:	Kansas City	1	0	8	10	0	0	4	1	0	0
	St. Louis	1	0	9	7	0	0	7	6	0	0
Mont:	Helena	1	0	6	6	0	0	8	10	1	3
Nebr:	Omaha	1	0	8	5	0	0	5	10	0	0
Nev:	Las Vegas	0	0	2	2	0	0	4	8	0	0
N. H:	Manchester	NA	NA	13	9	0	0	37	26	0	0
N. J:	Trenton	NA	NA	10	14	0	0	10	10	0	0
N. Mex:	Albuquerque	0	0	2	3	0	0	2	0	0	0
N. Y:	Buffalo	NA	NA	8	8	0	0	12	14	0	0
	New York City	NA	NA	10	11	0	0	14	15	0	0
	Syracuse	NA	NA	10	10	0	0	10	9	0	0
N. C:	Charlotte	0	0	16	15	1	0	14	18	0	0
N. Dak:	Minot	0	0	12	13	0	0	12	7	0	0
Ohio:	Cincinnati	NA	NA	9	8	0	0	6	7	0	0
	Cleveland	NA	NA	9	10	0	0	10	12	0	0
Okla:	Oklahoma City	0	0	10	10	0	0	4	4	0	0
Ore:	Portland	1	0	7	8	0	0	14	18	0	0
Pa:	Philadelphia	NA	NA	8	0	0	0	8	8	0	0
	Pittsburgh	NA	NA	12	10	0	0	15	11	0	0
P. R:	San Juan	0	0	5	3	0	0	12	10	0	0
R. I:	Providence	NA	NA	11	12	0	0	20	10	0	0
S. C:	Charleston	0	0	15	15	0	0	30	28	0	0
S. Dak:	Rapid City	2	0	11	10	0	0	10	10	0	0
Tenn:	Chattanooga	0	0	15	13	0	0	14	14	0	0
	Memphis	0	0	12	14	0	0	5	8	0	0
Tex:	Austin	0	0	4	4	0	0	4	2	0	0
	Dallas	0	NA	8	0	0	0	13	11	0	0
Utah:	Salt Lake City	1	0	5	5	0	0	13	15	0	0
Va:	Norfolk	0	0	10	12	0	0	19	3	0	0
Vt:	Burlington	NA	NA	11	10	0	0	11	7	0	0
Wash:	Seattle	2	0	9	7	0	0	25	18	1	0
	Spokane	0	0	8	3	0	0	14	10	0	0
W. Va:	Charleston	0	0	11	10	0	0	6	3	0	0
Wisc:	Milwaukee	NA	NA	8	7	0	0	12	8	0	0
Wyo:	Laramie	0	0	5	4	0	0	6	3	0	0
Network monthly average		0	0	9	9	0	0	13	11	0	0

* See text for averaging procedure.
 † 12 month averages represent only 9-months data.
 NA, no analysis.

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were deter-

mined by comparing results of a large number of replicate analyses. Table 2 contains averages for April 1968 and 12-month averages for the period May 1967 through April 1968. The

12-month averages facilitate evaluations of population exposure with respect to the guidance provided by the Federal Radiation Council, which suggests average total daily intakes "averaged over periods of the order of a year," as an appropriate criterion (3). The average radionuclide concentrations are based on results obtained from samples collected weekly. Whenever weekly concentrations were less than or equal to the appropriate minimum detectable levels, zero was used for averaging purposes (2). At very low radionuclide concentrations this often results in averages lower than the minimum detectable concentration for a single

sample, but any positive value reflects at least one weekly sample which was above the minimum detectable level. The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium-89, 5; strontium-90, 2; cesium-137, barium-140, and iodine-131, 10. Iodine-131 is not shown in table 2 as the concentrations were below detectable levels.

The average strontium-90 concentrations in pasteurized milk from selected cities are presented in figure 2.

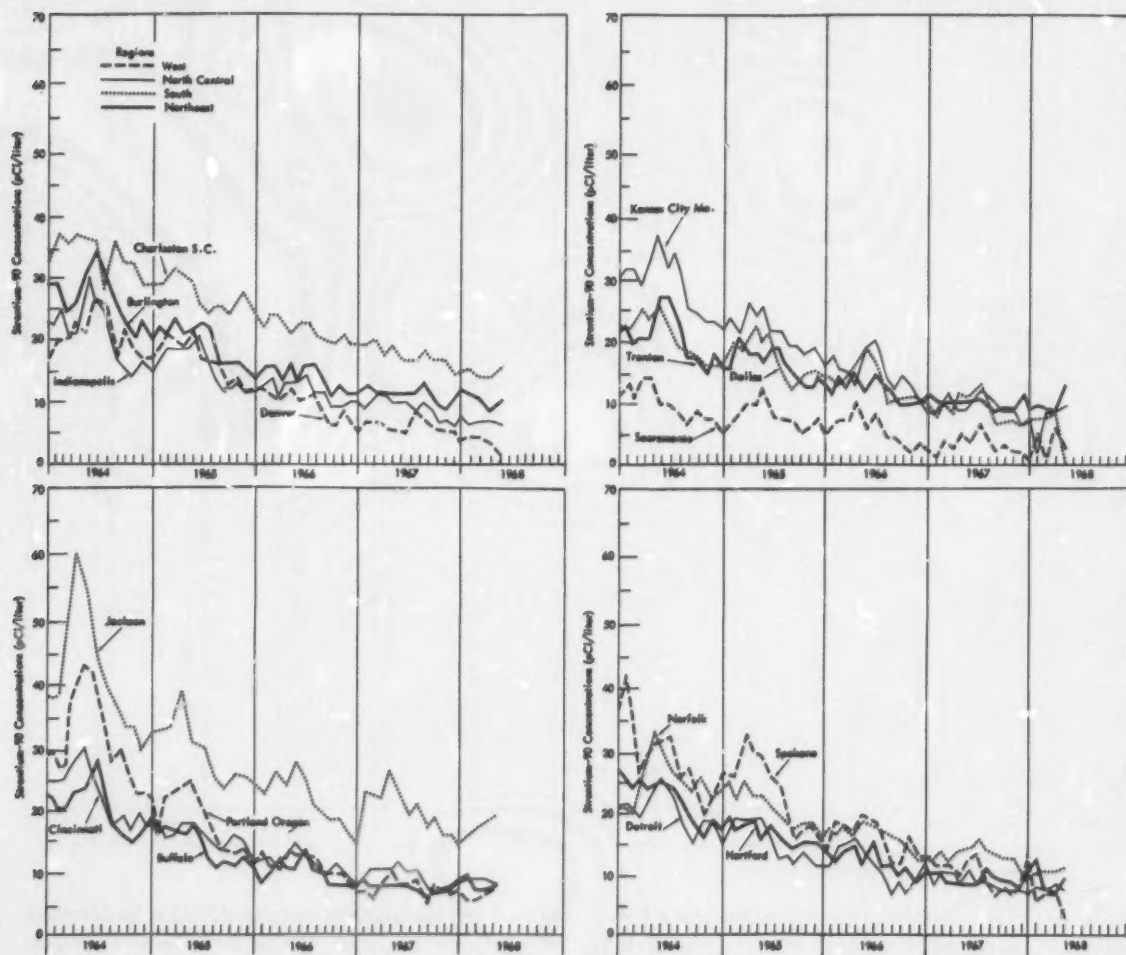


Figure 2. Strontium-90 concentrations in pasteurized milk, 1964-April 1968

2. Canadian Milk Network April 1968¹

*Radiation Protection Division
Department of National Health and Welfare*

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and potassium. The analytical pro-

cedures were outlined in the April 1968 issue of *Radiological Health Data and Reports* (4).

The April 1968 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 3. Iodine-131 concentrations were below minimum detectable levels. Due to the low environmental levels currently present, strontium-89 analysis has been discontinued.

Table 3. Stable elements and radionuclides in Canadian whole milk, April 1968

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.15	1.4	8	15
Edmonton	1.13	1.5	8	19
Ft. William	1.10	1.4	14	28
Fredrickton	1.07	1.6	15	25
Halifax	1.00	1.5	11	24
Montreal	1.00	1.5	10	21
Ottawa	1.13	1.5	8	14
Quebec	1.09	1.5	15	20
Regina	1.09	1.5	6	14
St. John's, Nfld.	1.11	1.4	17	30
Saskatoon	1.10	1.5	8	17
Sault Ste. Marie	1.08	1.5	15	23
Toronto	1.09	1.5	5	12
Vancouver	1.11	1.5	14	47
Windsor	1.15	1.4	6	10
Winnipeg	1.08	1.6	8	23

¹ Prepared from May 1968 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.



Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program April 1968

*Pan American Health Organization and
U.S. Public Health Service*

The Pan American Health Organization (PAHO) in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures em-

ployed was presented in the December 1966 issue of *Radiological Health Data and Reports* (5).

Table 4 presents stable potassium, strontium-90 and cesium-137 monthly concentrations for April 1968.

Table 4. Stable element and radionuclide concentration in Pan American milk,^a April 1968

Sampling station	Number of samples	Potassium (g/liter)	Strontium-90 ^b (pCi/liter)	Cesium-137 ^b (pCi/liter)
Chile: Santiago.....	1	1.62	0	0
Colombia: Bogota.....	1	1.44	0	0
Ecuador: Guayaquil.....	1	1.50	0	0
Jamaica: Kingston.....	1	1.51	4	60
Venezuela: Caracas.....	1	1.59	0	0
Canal Zone: Cristobal ^c ..	5	1.47	0	3
Puerto Rico: San Juan ^c ..	5	1.60	3	11

^a All strontium-90 results were ≤ 5 pCi/liter; iodine-131 and barium-140 results were all ≤ 10 pCi/liter.

^b Strontium-90 single sample results ≤ 2 pCi/liter and cesium-137 single sample results ≤ 10 pCi/liter are reported as 0.

^c For comparison, the radionuclide concentrations in Pasteurized Milk Network samples collected at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.



Figure 4. Pan American Milk Sampling Program stations

4. Radiostrontium in milk January-December 1967¹

*Health and Safety Laboratory
U.S. Atomic Energy Commission*

In 1954, the Health and Safety Laboratory began monitoring strontium-90 in liquid whole milk in New York to estimate the dietary contribution from ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, N.Y. (1954), and

at Mandan, N. Dak. (1955). Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959. Sampling was terminated at Mandan, N. Dak., and Honolulu, Hawaii at the end of June 1965.

¹ Data summarized from "Fallout Program Quarterly Summary Report," HASL-193, available from Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

Table 7. Strontium-90 to calcium ratios in milk, January-December 1967

Sampling location	Strontium-90 to calcium ratio (pCi ⁹⁰ Sr/g Ca)											
	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
New York, N.Y. (liquid whole milk)...	13.5	9.6	11.1	10.9	9.7	—	—	—	12.2	7.6	7.8	7.4
Perry, N.Y. (powdered whole milk).	9.5	8.9	9.8	7.6	8.2	8.5	7.5	9.3	8.1	8.6	7.5	7.1

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Perry samples are monthly composites of powdered whole milk for human consumption collected weekly in 5-pound lots from plants in the city. The strontium-90 to calcium ratios in whole milk are presented in table 7.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January-June 1966	March 1967
July-December 1966	September 1967

REFERENCES

- (1) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, September 1967. Radiol Health Data Rep 9:20-23 (January 1968).
- (2) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, October 1967. Radiol Health Data Rep 9:86-89 (February 1968).
- (3) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).
- (4) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian milk network, August 1966. Radiol Health Data Rep 7:702-703 (December 1966).
- (5) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704-705 (December 1966).

State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing develop-

mental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows the States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs appearing in this issue are highlighted in the figure. Following is a summary of previously covered State programs, their reporting period, and the last issue in which they appeared.

<u>State milk network</u>	<u>Period reported</u>	<u>Last presented</u>
Colorado	January-March 1968	July 1968
Florida	January-March 1968	July 1968
Oklahoma	October-December 1967	April 1968
Tennessee	January-March 1968	July 1968
Texas	January-March 1968	July 1968
Washington	October-December 1967	June 1968
California	October-December 1967	June 1968
Oregon	October-December 1967	June 1968

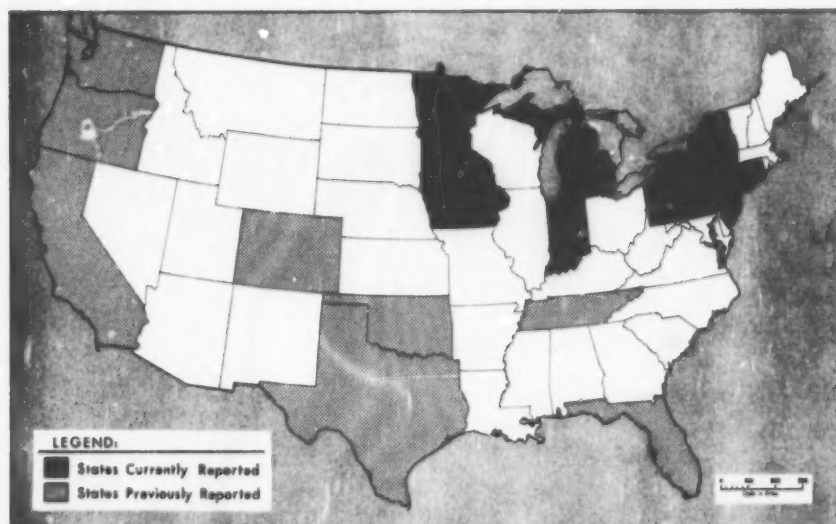


Figure 1. State milk surveillance activities

1. Connecticut Milk Network January-March 1968

Connecticut State Department of Health

The Connecticut State Department of Health has been monitoring pasteurized milk for strontium-89 and strontium-90 since April 1960. In May 1962, the program was expanded to include the determination of gamma-emitting radionuclides in milk.

The sampling program is flexible in nature, providing for sampling in five areas of the State (figure 2). At the present time, weekly samples representative of milk sold in the central area of the State are collected and analyzed for strontium-89, strontium-90, and gamma-ray emitters. Concentrations of iodine-131 are determined as an indication of the presence of radioactivity of recent origin.

Strontium-89 and strontium-90 are determined by chemical separation. Iodine-131 and other gamma-ray emitters are determined by gamma-ray scintillation spectroscopy.

The monthly average concentrations of strontium-89, strontium-90, iodine-131, and cesium-137 in central Connecticut pasteurized milk are presented in table 1. These results are presented graphically in figure 3.

Table 1. Radionuclide concentrations in central Connecticut pasteurized milk, January-March 1968

Month	Concentration (pCi/liter)			
	Strontium-89	Strontium-90	Iodine-131	Cesium-137
January	ND	7	<10	15
February	ND	8	<10	10
March	ND	7	<10	10



Figure 3. Radionuclide concentrations in central Connecticut pasteurized milk, 1964-March 1968

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July-September 1967	February 1968
October-December 1967	May 1968

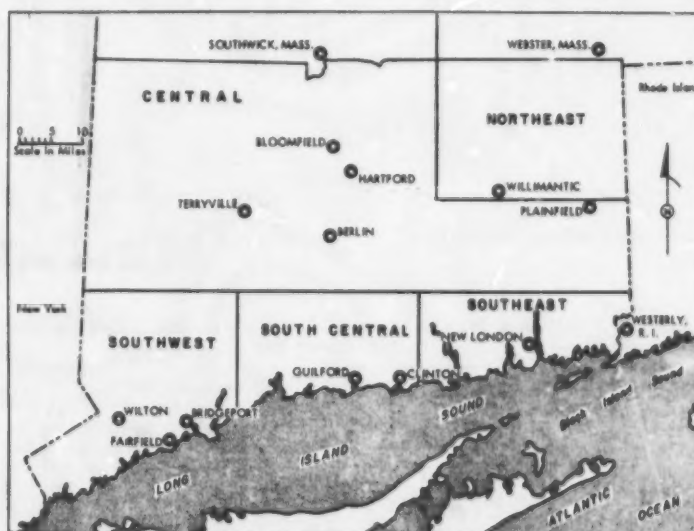


Figure 2. Connecticut pasteurized milk sampling areas

2. Indiana Milk Network January-March 1968

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. The State was geographically divided into five major milksheds; northeast, northwest, central, southeast, southwest;

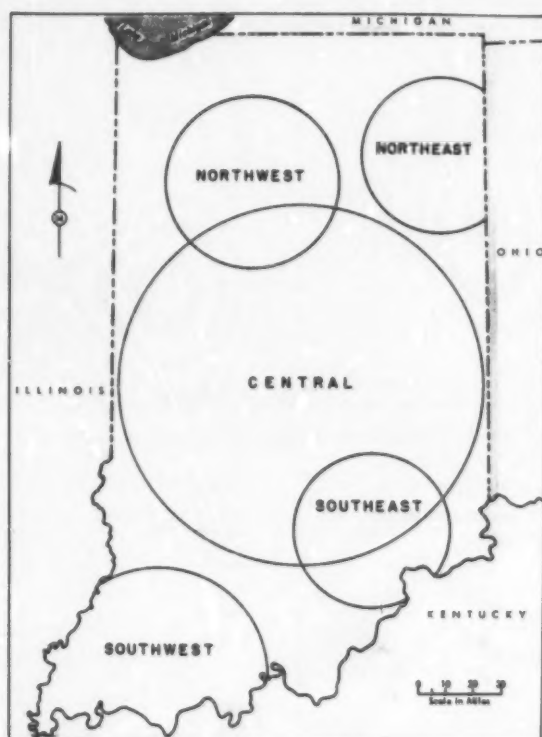


Figure 4. Indiana pasteurized milk sampling areas

and southwest (figure 4). One large dairy within each milkshed was assumed to be representative for sampling purposes.

The milk samples are analyzed monthly for strontium-89 and strontium-90. Cesium-137, iodine-131, and barium-140 are analyzed weekly for at least two of the milksheds. When iodine-131 concentrations exceed 100 pCi/liter, the sampling frequency is increased. From August 1963 to April 1966, because of the continued low concentrations of short-lived radionuclides, the sampling frequency was once a month for the northeast, southeast, and southwest milksheds.

Strontium-89 and strontium-90 concentrations in milk samples are determined by ion exchange separation (1, 2) while cesium-137, iodine-131, and barium-140 are determined by gamma-ray scintillation spectrometry (3).

The monthly stable elements and radionuclide concentrations in Indiana pasteurized milk are presented by sampling locations in table 2 for January through March 1968. Barium-140, iodine-131 and strontium-89 concentrations remained below detectable levels of 10 pCi/liter during this period.

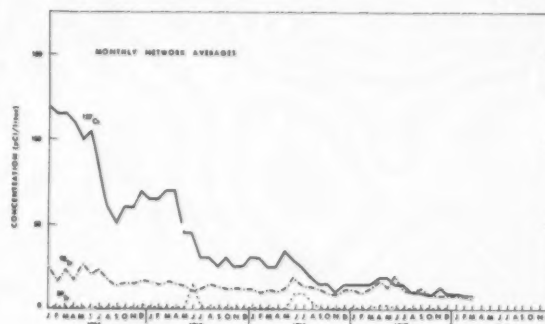


Figure 5. Radionuclide concentrations in Indiana pasteurized milk, 1964-March 1968

Table 2. Stable elements and radionuclide concentrations in Indiana milk
January-March 1968

Sampling location	Calcium (g/liter)			Potassium (g/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Northeast	1.10	1.18	1.17	1.49	1.62	1.52	7	8	7	5	5	10
Southeast	1.17	1.20	1.24	1.47	1.51	1.67	9	10	6	5	15	10
Central	1.21	1.25	1.28	1.53	1.56	1.48	9	7	6	10	10	5
Southwest	1.14	1.18	1.18	1.52	1.50	1.58	10	10	8	20	5	10
Northwest	1.26	1.20	1.42	1.57	1.57	1.51	8	8	7	10	10	10

The monthly network average concentrations of strontium-89, strontium-90, and cesium-137 are presented graphically in figure 5.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July-September 1967	February 1968
October-December 1967	May 1968

3. Iowa Milk Network January March 1968

*State Hygienic Laboratory and the
Iowa State Department of Health*

In Iowa, radiological health activities are conducted jointly by the State Department of Health and the State Hygienic Laboratory, with the State Hygienic Laboratory performing the surveillance and analytical functions.

In August 1962 the State Hygienic Laboratory of Iowa began sampling milk for iodine-131. In May 1964 this routine surveillance was expanded to include cesium-137 and strontium-90.

One gallon samples are collected from 4 stations, selected to give a broad coverage of milk production areas in the State (figure 6). Producers furnishing milk to the Spencer bottling area are quite restricted to that northwest part of the state and the majority of milk bottled in Iowa City comes from six counties in east central Iowa. The Des Moines milkshed comprises approximately sixty counties covering

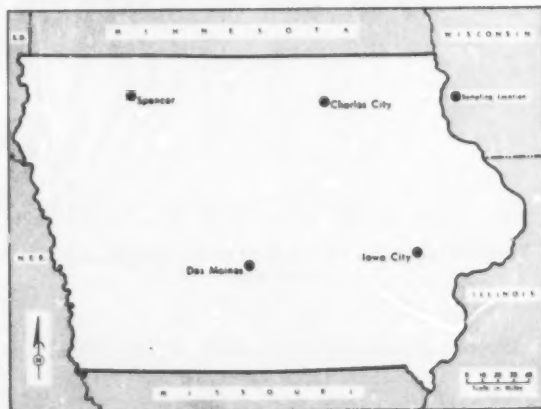


Figure 6. Iowa milk sampling locations

August 1968

about two thirds of the state radiating out of Des Moines in all directions. The Charles City bottling area covers primarily north central Iowa. At present the Iowa City and Des Moines stations are sampled weekly and the Spencer and Charles City stations are sampled monthly. The sampling frequency is increased when nuclide concentrations warrant closer surveillance. The samples are forwarded to the State Hygienic Laboratory at the University of Iowa, Iowa City for analysis.

Analytical procedures

Iodine-131 and cesium-137 together with barium-lanthanum-140 and potassium-40 are determined by gamma-scintillation spectrometry using a 4- by 4-inch NaI (Tl) crystal and 512 channel pulse height analyzer. All samples are 3.5 liters and are counted for 80 minutes in Marinelli beakers with the results being calculated using a 4 by 4 matrix. Strontium-90 is determined by an ion-exchange system described by Porter, et al (4). One liter of milk is passed through an ion-exchange column; yttrium-90 is eluted from the resin and counted as yttrium oxalate in an automatic low background proportional counter. Minimum detectable limits are 10 pCi/liter for iodine-131 and cesium-137 and 2 pCi/liter for strontium-90.

Results

Table 3 gives the monthly averages at each of the four locations for January-March 1968 and figure 7 shows graphically the overall network average monthly results. During this period it can be seen that the concentration levels of cesium-137 and strontium-90 showed a decreasing trend. Iodine-131 was only present to any significant amount during the month of June 1965.

90

Table 3. Radionuclide concentrations in Iowa milk January-March 1968

Sampling location	Concentration (pCi/liter)								
	Strontium-90			Cesium-137			Iodine-131		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Iowa City.....	6	6	7	<10	<10	<10	<10	<10	<10
Des Moines.....	7	7	5	<10	<10	<10	<10	<10	<10
Spencer.....	5	8	8	<10	<10	<10	<10	<10	<10
Charles City.....	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA, no analysis.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July-September 1967	February 1968
October-December 1967	May 1968

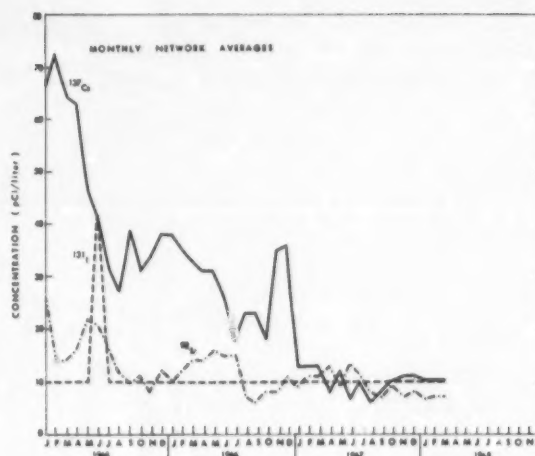


Figure 7. Radionuclide concentrations in Iowa milk 1965-March 1968

4. Michigan Milk Network January-March 1968

*Division of Occupational Health
Michigan Department of Health*

The Michigan Department of Health began sampling pasteurized milk for radionuclide analyses in November 1962. Under this program, weekly pasteurized milk samples are collected in the seven major milk producing areas in the State: Charlevoix, Detroit, Grand Rapids, Lansing, Marquette, Monroe, and Saginaw (figure 8). Milkshed samples are composites of dairies in proportion to sales volumes.

Strontium-90 concentrations are determined by an ion exchange method (5). Potassium-40, iodine-131, cesium-137, and barium-lanthanum-140 concentrations are determined by gamma-ray scintillation spectrometry (5).

Table 4 presents the monthly average stable elements and radionuclide concentrations in Michigan pasteurized milk. Iodine-131 levels were less than the minimum detectable radioactivity (14 pCi/liter) for the period at all stations. Strontium-90 and cesium-137 concentrations are presented graphically in figure 9 to show general trends.



Figure 8. Michigan pasteurized milk network sampling locations

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July-September 1967	February 1968
October-December 1967	May 1968

Table 4. Stable element and radionuclide concentrations in Michigan pasteurized milk, January-March 1968

Sampling location	Month	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Charlevoix.....	January....	1.62	6	8
	February....	1.67	5	10
	March.....	1.69	5	13
Detroit.....	January....	1.69	6	5
	February....	1.68	4	7
	March.....	1.68	4	8
Grand Rapids....	January....	1.64	7	10
	February....	1.68	4	11
	March.....	1.65	5	9
Lansing.....	January....	1.65	5	8
	February....	1.72	3	4
	March.....	1.69	4	5
Marquette.....	January....	1.65	6	12
	February....	1.63	6	17
	March.....	1.65	7	16
Monroe.....	January....	1.65	4	5
	February....	1.70	3	8
	March.....	1.74	3	7
Bay City.....	January....	1.69	4	7
	February....	1.70	3	6
	March.....	1.72	5	7

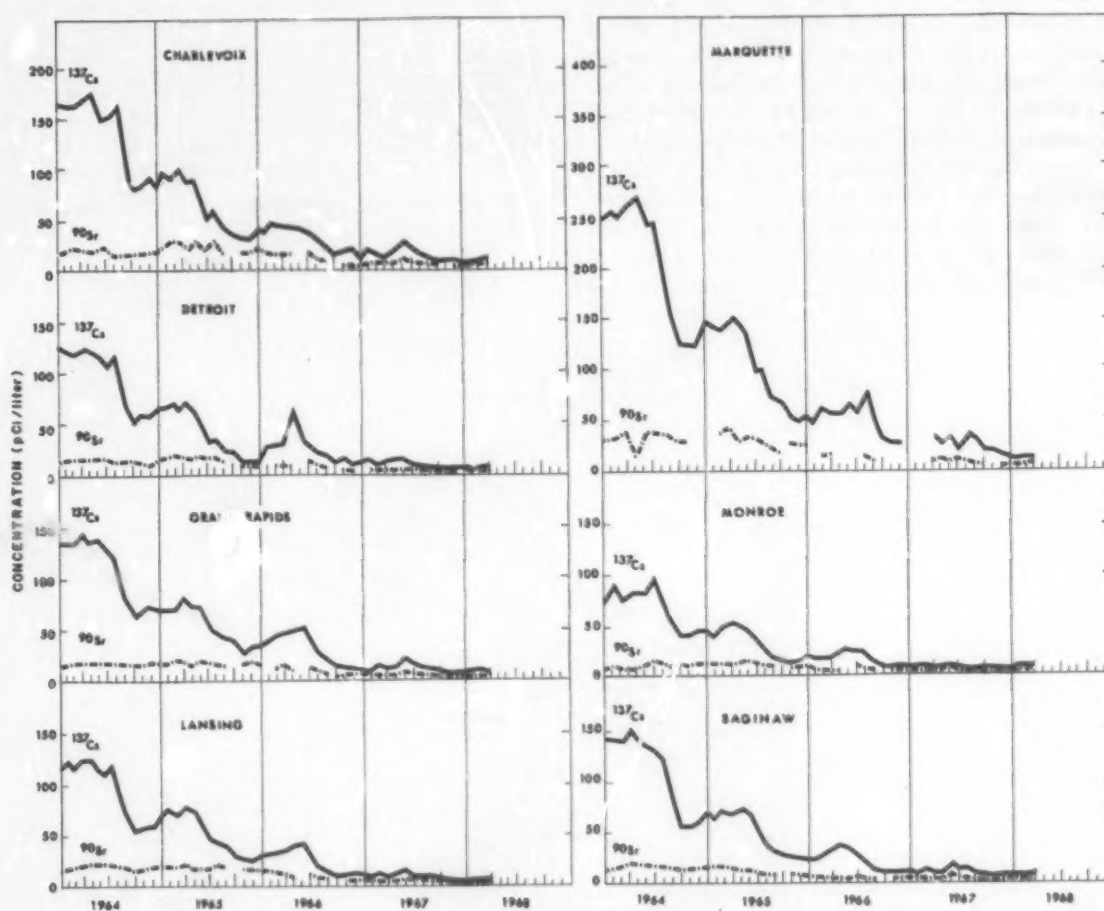


Figure 9. Radionuclide concentrations in Michigan pasteurized milk, 1964-March 1968

5. Minnesota Milk Network January-March 1968

*Division of Environmental Health
Minnesota Department of Health*

In September 1958, the Minnesota Department of Health initiated a pasteurized milk network to monitor strontium-90 concentrations. Monitoring of iodine-131 concentrations commenced in October 1961 and of cesium-137 concentrations in July 1963. Until recently, 1-liter samples were collected from eight sampling locations in milksheds geographically the same as the Minnesota health districts (figure 10) and analyzed for strontium-90, iodine-131 and cesium-137. The size of the sample has been increased to 2 quarts for more accurate determinations. The 2-quart samples of processed Grade A fluid milk are collected in the cities where the Minnesota Health Department district offices are located.

Strontium-90 concentrations are determined radiochemically, while iodine-131 and cesium-137 concentrations are determined by gamma-ray scintillation spectrometry. The analytical procedures are presented in the semiannual re-

port of the Minnesota Department of Health and the Rural Cooperative Power Association (6).

Strontium-90, and cesium-137 concentrations in milk are given for January through March 1968 in table 5, and are presented graphically by milkshed in figure 11 for the period 1961 through March 1968. Iodine-131 concentrations were less than 10 pCi/liter in all 24 samples.

Table 5. Radionuclide concentrations in Minnesota pasteurized milk, January-March 1968

Sampling stations	Radionuclide concentration (pCi/liter)					
	Strontium-90			Cesium-137		
	Jan	Feb	Mar	Jan	Feb	Mar
Bemidji.....	13	11	10	9	17	17
Mankato.....	6	5	5	6	11	10
Rochester.....	7	8	5	5	8	5
Duluth.....	16	20	16	14	34	19
Worthington.....	6	5	5	9	8	5
Minneapolis.....	10	10	9	9	9	8
Fergus Falls.....	8	7	6	8	7	8
Little Falls.....	8	6	8	8	13	12

Recent coverage in *Radiological Health Data and Reports*:

Period
July-September 1967
October-December 1967

Issue
February 1968
May 1968



Figure 10. Minnesota milk sampling locations

August 1968

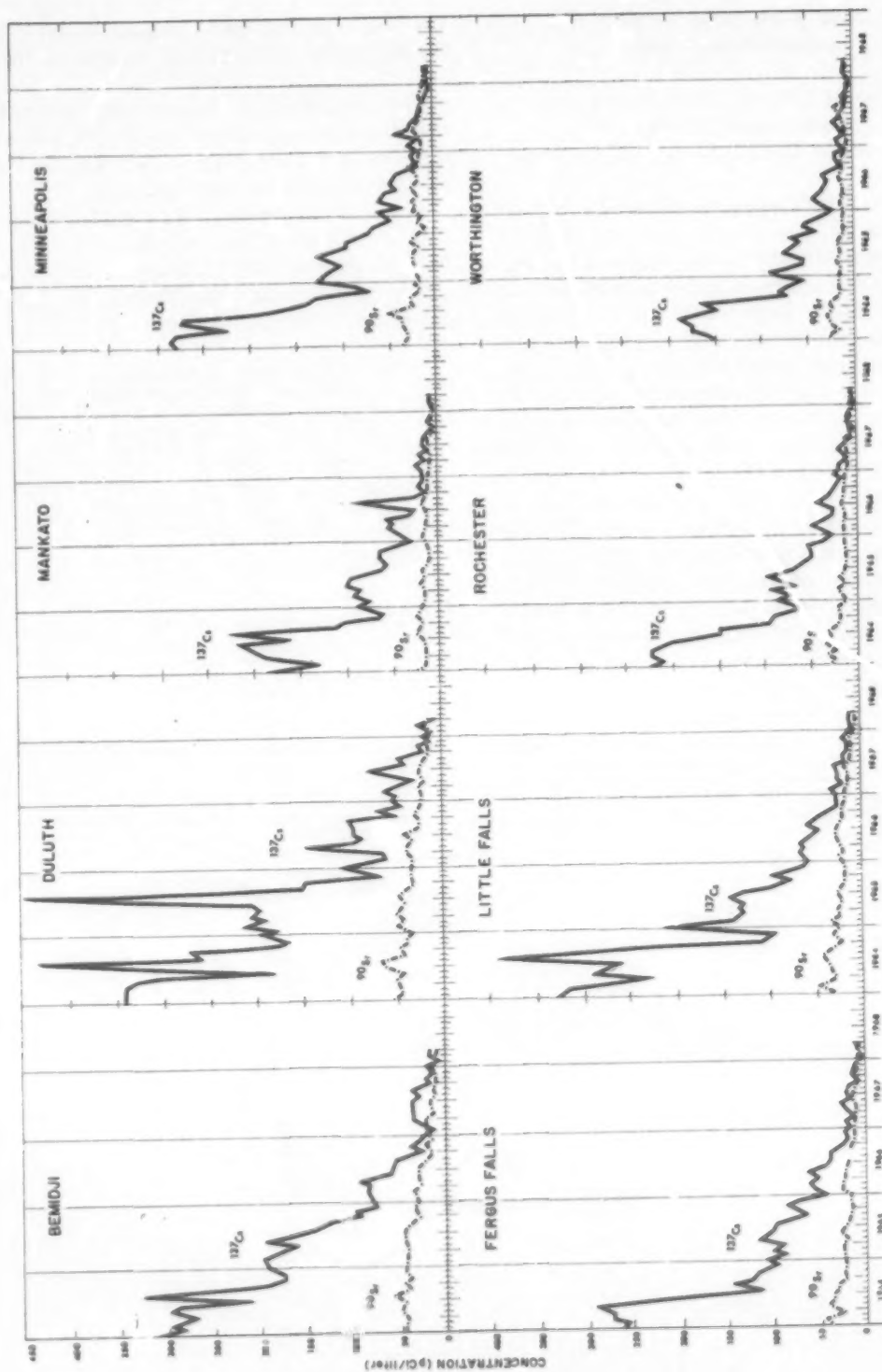


Figure 11. Radionucleide concentrations in Minnesota milk, 1964-March 1968

6. New York Milk Network January-March 1968

*Division of General Engineering and
Radiological Health
Department of Health, State of New York*

Pasteurized milk samples collected routinely from six cities (figure 12) are analyzed for strontium-89, strontium-90, iodine-131, cesium-137 and barium-lanthanum-140 by the New York State Department of Health. At Buffalo and Newburgh, milk samples are collected daily from processing plants and composited weekly for radiochemical analyses. At Massena and Syracuse daily samples are composited over a two week period and then analyzed. In New York City, a milk sample representing the total milk supply for 1 day is analyzed weekly. The Albany sample, taken at a marketing point, is analyzed daily for iodine-131 and other gamma-ray emitting radionuclides before being composited into a weekly sample. In the event that any sample contains iodine-131 concentrations exceeding 100 pCi/liter, increased surveillance is undertaken.

Gamma-ray emitting radionuclides in milk are determined by scintillation spectrometry. Radioiodine is selectively removed in an anion exchange resin and the resin is analyzed for iodine-131 (7, 9). The resin effluent is analyzed

and the resulting spectral data is resolved by the application of a matrix method of analysis (8).

The analytical procedure for determining strontium-89 and strontium-90 concentrations employs an ion-exchange system similar to that developed by Porter and Kahn (2).

The concentrations of strontium-90 and cesium-137 are shown in table 6 for January through March 1968. Cesium-137 and iodine-131 concentrations since September 1961 are presented graphically in figure 13.

Table 6. Radionuclide concentrations in New York pasteurized milk, January-March 1968

Sampling location	Radionuclide concentrations (pCi/liter)			
	Strontium-90		Cesium-137	
	Number of samples	Average	Number of samples	Average
Albany.....	10	7	6	ND
Buffalo.....	6	7	4	20
Massena.....	5	10	5	ND
Newburgh.....	10	8	4	ND
New York.....	10	12	5	21
Syracuse.....	3	11	3	20

ND, nondetectable. Detectable limits for strontium-90 and cesium-137 are 3 pCi/liter and .20 pCi/liter, respectively.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
April-June 1967	November 1967
December 1967	May 1968

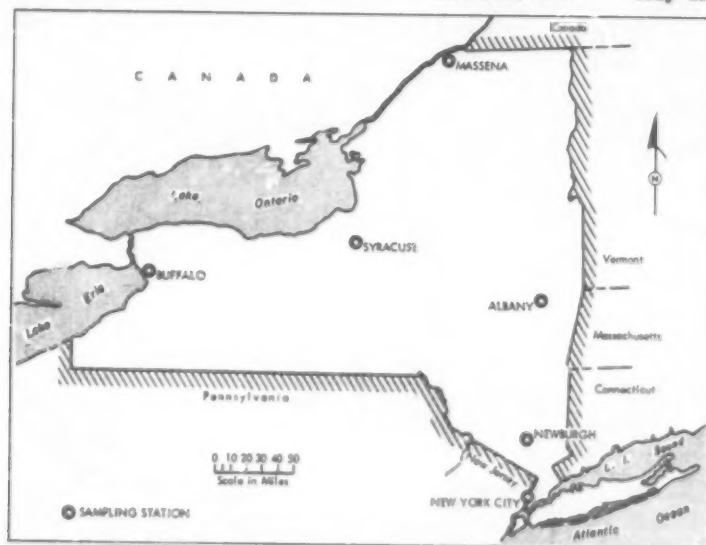


Figure 12. New York milk sampling locations

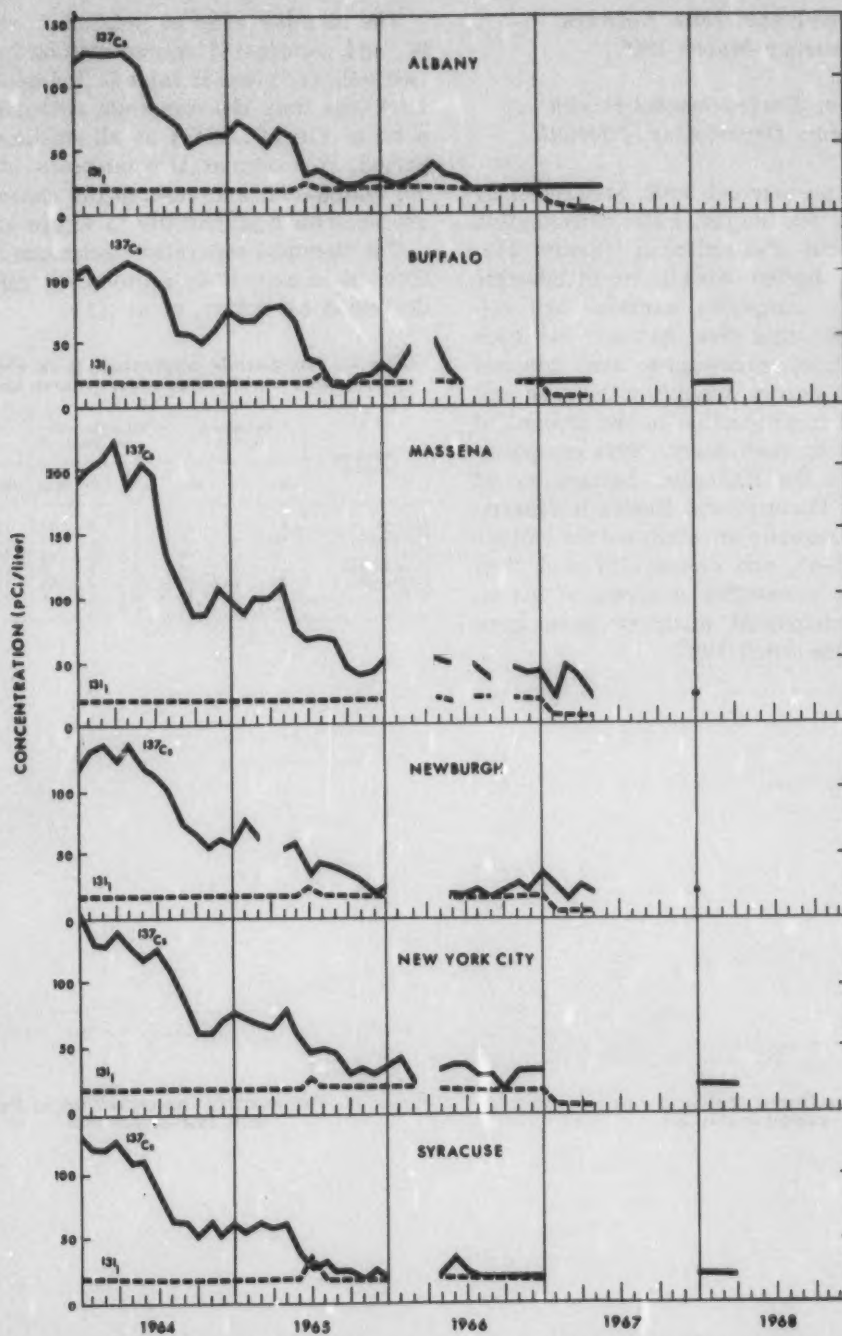


Figure 13. Radionuclide concentrations in New York milk, 1964-March 1968

7. Pennsylvania Milk Network January-March 1968

Bureau of Environmental Health
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from six major milk consumption areas throughout Pennsylvania (figure 14). Samples are collected weekly in Pittsburgh, while biweekly composite samples are collected from the other five stations. At each sampling location, subsamples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg where the samples are analyzed for iodine-131, potassium-40, and cesium-137 and then composited for a monthly analysis of strontium-90. Strontium-90 analyses have been carried out since April 1963.

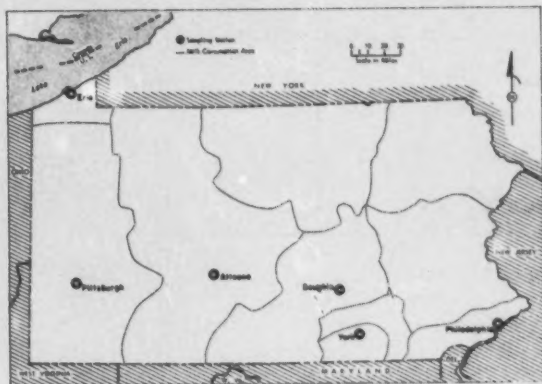


Figure 14. Pennsylvania pasteurized milk network sampling stations

The monthly average potassium-40, strontium-90, and cesium-137 concentrations in pasteurized milk are given in table 7. Iodine-131 levels were less than the minimum detectable radioactivity (10 pCi/liter) at all stations for this period. For comparative purposes, strontium-90, iodine-131, and cesium-137 concentrations are presented graphically in figure 15.

The chemical separation technique for strontium-90 is essentially an ion-exchange method described by Porter, et al. (1).

Table 7. Radionuclide concentrations in Pennsylvania pasteurized milk, January-March 1968

Sampling location	Potassium (g/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Altoona	1.61	1.50	1.65	6	6	6	13	13	11
Dauphin	1.60	1.68	1.60	6	6	5	11	8	10
Erie	1.53	1.66	1.64	6	13	13	14	12	13
Philadelphia	1.54	1.57	1.52	5	5	8	14	11	14
Pittsburgh	1.54	1.59	1.58	10	7	13	11	12	16
York	1.57	1.69	1.50	3	4	7	15	15	15

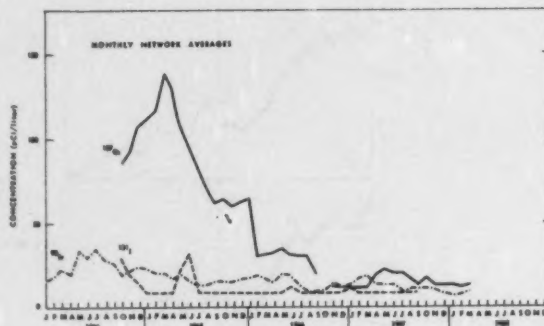


Figure 15. Radionuclide concentrations in Pennsylvania milk, 1964-March 1968

Recent coverage in *Radiological Health Data and Reports*:

Period
July-September 1967
October-December 1967

Issue
February 1968
May 1968

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- (8) KAHN, B., G. K. MURTHY, C. PORTER, G. R. HAGEE, G. J. KARCHES, and A. S. GOLDIN. Rapid methods for estimating fission product concentrations in milk. PHS Publication No. 999-R-2 (March 1963).
- (9) PORTER, C. R., and M. W. CARTER. Field method for rapid collection of iodine-131 from milk. *Public Health Rep* 80:453-456 (May 1965).

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

<u>Program</u>	<u>Period Reported</u>	<u>Last presented</u>
California Diet Study	July-October 1967	May 1968
Connecticut Standard Diet	July-December 1967	May 1968
Institutional Total Diet	October-December and annual summary	July 1968
Tri-City Diet, HASL	April-December 1967	June 1968

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determination of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (1). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (2-4), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively.

Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence¹ of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

¹ Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

<u>Water sampling program</u>	<u>Period reported</u>	<u>Last presented</u>
California	January-June 1967	June 1968
Colorado River Basin	1965-1966	May 1968
Coast Guard	January-December 1966	November 1967
Florida	1965-1966	July 1968
Minnesota	January-June 1967	January 1968
New York	January-May 1967	January 1968
Radiostrontium in Tap Water, HASL	July-December 1967	June 1968

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Gross Radioactivity in Surface Waters of the United States, February 1968

*Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of the Interior*

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semi-annually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus dissolved solids in raw water collected at

each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (1-6). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity concentration is 15 pCi/liter or greater or when the beta radioactivity concentration is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes

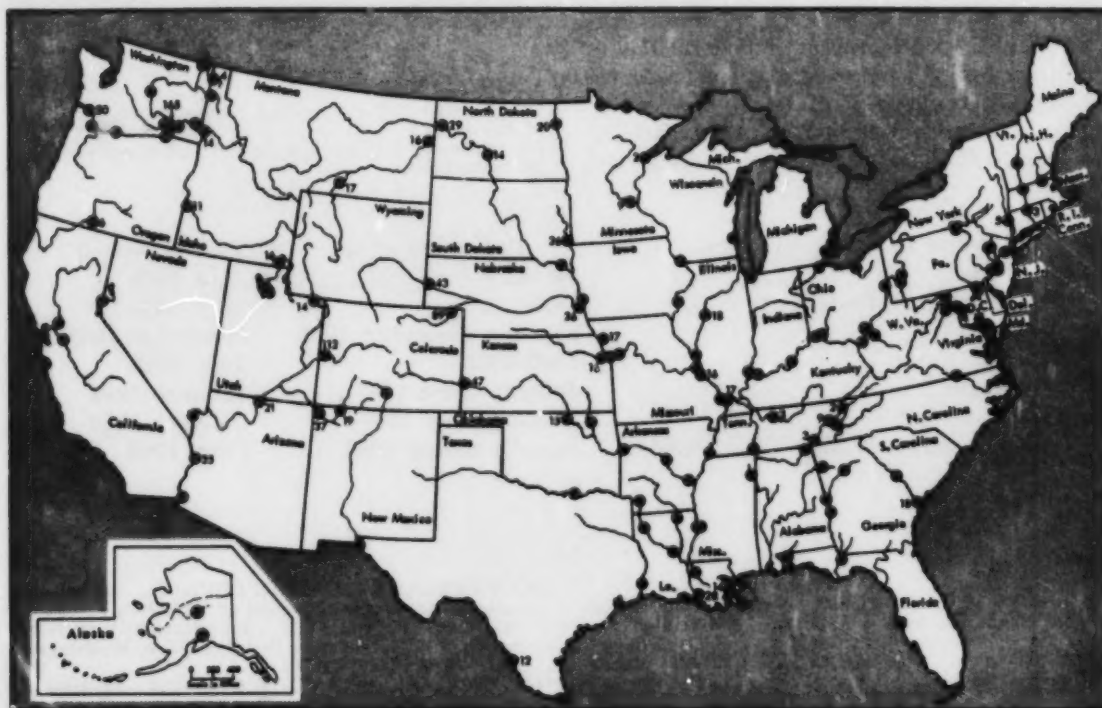


Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, February 1968

from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (7). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During February 1968, the following stations showed values in excess of 15 pCi/liter of alpha radioactivity for dissolved solids:

Arkansas River; Coolidge, Kans.
North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

During February 1968, Pasco, Wash., on the Columbia River decreased in average beta

radioactivity to slightly less than 150 pCi/liter in dissolved solids.

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- (4) Ibid., 1961 Edition.
- (5) Ibid., 1962 Edition.
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Table 1. Radioactivity in raw surface waters, February 1968

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	2	1	3	11	8	19
Arkansas River:						
Coolidge, Kans.	1	23	24	6	41	47
Ponca City, Okla.	0	2	2	1	14	15
Atchafalaya River:						
Morgan City, La.	4	1	5	21	7	28
Bear River:						
Preston, Idaho	0	2	2	1	15	16
Big Horn River:						
Hardin, Mont.	1	2	3	3	14	17
Big Sioux River:						
Sioux Falls, S. Dak.	0	2	2	<1	26	26
Clearwater River:						
Lewiston, Idaho	2	0	2	7	7	14
Clinch River:						
Clinton, Tenn.	0	0	0	0	2	2
Kingston, Tenn.	0	0	0	1	8	9
Colorado River:						
Loama, Colo.	10	6	16	36	76	112
Pago, Ariz.	1	5	6	1	20	21
Parker Dam, Calif.						
Ariz.	0	5	5	1	24	25
Columbia River:						
Pasco, Wash.	<1	<1	<1	20	145	165
Catawba, Ore.	0	0	0	7	13	20
Connecticut River:						
Enfield Dam, Conn.	0	0	0	1	2	3
Cumberland River:						
Chatham Lock:						
Tenn.	0	0	0	1	2	3
Great Lakes:						
Duluth, Minn.	0	0	0	0	2	2
Green River:						
Dutch John, Utah	1	2	3	1	13	14
Hudson River:						
Poughkeepsie, N. Y.	0	0	0	0	5	5
Illinois River:						
Peoria, Ill.	2	0	2	8	10	18
Kansas River:						
DeSoto, Kans.	0	4	4	1	15	16
Klamath River:						
Keno, Ore.	0	0	0	1	5	6
Mississippi River:						
St. Paul, Minn.	0	1	1	0	9	9
E. St. Louis, Ill.	2	1	3	7	9	16
New Orleans, La.	1	0	1	7	7	14
Missouri River:						
Williston, N. Dak.	5	2	7	19	10	29
Bismarck, N. Dak.	<1	3	3	1	13	14
St. Joseph, Mo.	1	2	3	3	14	17
North Platte River:						
Henry, Nebr.	<1	30	30	4	39	43
Ohio River:						
Cairo, Ill.	2	0	2	11	6	17
Pend Oreille River:						
Albion Falls Dam, Idaho	0	<1	<1	<1	4	4
Platte River:						
Plattsmouth, Nebr.	2	3	5	9	17	26
Potomac River:						
Washington, D. C.	0	0	0	1	3	4
Red River, North:						
Grand Forks, N. Dak.	0	1	1	1	19	20
Rio Grande:						
Laredo, Tex.	0	4	4	1	11	12
San Juan River:						
Shiprock, N. Mex.	12	2	14	29	8	37
Savannah River:						
Port Wentworth, Ga.	<1	0	<1	4	14	15
Snake River:						
Payette, Idaho	1	1	2	2	9	11
South Platte River:						
Julesburg, Colo.	3	43	46	15	74	89
Tennessee River:						
Chattanooga, Tenn.	0	<1	<1	<1	3	3
Yellowstone River:						
Sidney, Mont.	0	4	4	1	15	16
Maximum	12	43	46	36	145	165
Minimum	0	0	0	0	2	2

* Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

Radioactivity in Washington Surface Water, July 1966-June 1967¹

Washington State Department of Health

Radioanalysis of surface water samples collected throughout the State of Washington is one of the major functions of the Washington State Department of Health radiation surveillance program. Most surface water samples are collected quarterly or semiannually by the Washington State Water Pollution Control Commission. Selected stations on the Columbia River are sampled weekly or monthly by local health departments. Cedar River, a major water supply for the greater Seattle area, is sampled monthly by the City of Seattle Water Department.

All surface water samples are collected as grab samples in 2-liter polyethylene bottles. To prevent loss of radioactivity to the container, 2 milliliters of concentrated nitric acid are added to the sample before shipment to the State laboratory in Seattle for analysis.

Analytical procedures

Surface water samples are divided into two groups: those samples coming from the Columbia River and those samples coming from waters other than the Columbia River. The latter samples are placed in stainless-steel Marinelli beakers for gamma-ray spectroscopy analysis as soon after receipt as possible. Distilled water is added when necessary to obtain a standardized counting geometry of 2 liters. Table 1 gives the gamma-ray efficiencies and detection limits for the gamma-ray spectrometer. After gamma-ray analysis, the samples

are filtered through Whatman No. 42 filter paper. The filter paper containing the suspended solids is ashed in a muffle furnace, transferred to a tared planchet, weighed, and counted for gross beta radioactivity. The filtrate is evaporated to near dryness, quantitatively transferred to a tared planchet, dried, weighed, and counted for gross beta radioactivity.

Columbia River water is analyzed for gamma radioactivity approximately 14 days after collection. This delay allows the short-lived radionuclides, sodium-24, arsenic-76, and neptunium-239 to decay, leaving a less complex spectrum which can be evaluated without computer assistance. Following gamma radioanalysis, the Columbia River samples are divided into two aliquots for further analysis. One aliquot is prepared for phosphorus-32 analysis and the other is analyzed for gross beta radioactivity by the methods described above. Gross beta particle counting for all samples is performed 18 days after collection.

The phosphorus-32 analysis, a modification of published methods (1-4), begins 15 days after sample collection to allow arsenic-76 and other short-lived radionuclides to decay. The phosphorus is separated from interfering nuclides by precipitation as ammonium phos-

¹ Summarized from "Environmental Radiation Surveillance Quarterly Reports and Fifth Annual Report, December 1966."

Table 1. Beta-particle and gamma-ray efficiencies and detectability limits for the Washington State analyses

Radionuclide	Energy band (MeV)	Efficiency (percent)	Average background (cpm)	Detectability limits (pCi)
Beta				
Strontium-90-yttrium-90	-	34	0.5	• 0.31
Yttrium-90	-	38	.5	• .28
Phosphorus-32	-	35	.5	• .30
Gamma				
Chromium-51	0.30-0.36	0.53	23.18	• 200
Ruthenium-106	0.44-0.56	.91	22.36	• 100
Cesium-137	0.62-0.72	2.75	11.18	• 30
Zirconium-95	0.73-0.79	6.96	5.72	• 10
Zinc-65	1.06-1.17	1.06	6.38	• 40

* Amount of radiation necessary to produce a net cpm equal to 2 sigma of background, based on 100 minute counts.

• Amount of radiation necessary to produce a net cpm equal to 4 sigma of the respective background, based on 100 minute counts.

phomolybdate from an acid medium. The precipitate is washed with ammonium nitrate, dissolved with 3N ammonium hydroxide, transferred to a tared planchet, dried, ashed at 450° C., and counted for beta radioactivity.

Results

Table 2 presents the monthly average results for seven Columbia River stations which are sampled routinely. In averaging, a less-than value is assumed to be equal to its numerical value and a less-than sign is placed in front of the average.

Table 3 summarizes the beta radioactivity measurements from 35 other surface water stations from July 1966 through June 1967. The second column in this table gives code numbers and the abbreviations denoting geographical sections (figure 1). Each river is assigned a four digit number; the first two digits indicate the river and the second two digits indicate the sampling stations on the

river. For example, code number 04 refers to the Snake River in the area designated "RSE", i.e., Southeast. The code number 01 refers to the first sampling station on that river. The third column gives the total number of samples analyzed. Gross beta radioactivity results are not extrapolated to the date of collection.

Table 4 lists six samples which showed gamma radioactivity ranging from eight cpm/liter to fourteen cpm/liter (the other 169 samples were all less than five cpm/liter). The two samples collected on January 4 and January 5, 1967 from the Puyallup River and the Snake River respectively showed definite fallout from the foreign nuclear detonation of December 24, 1966. The other four samples showing detectable gamma radioactivity could not be attributed to any single event.

The network summary gives the maximum and minimum values for the 175 samples analyzed, while the network average is obtained by averaging all the station average values.

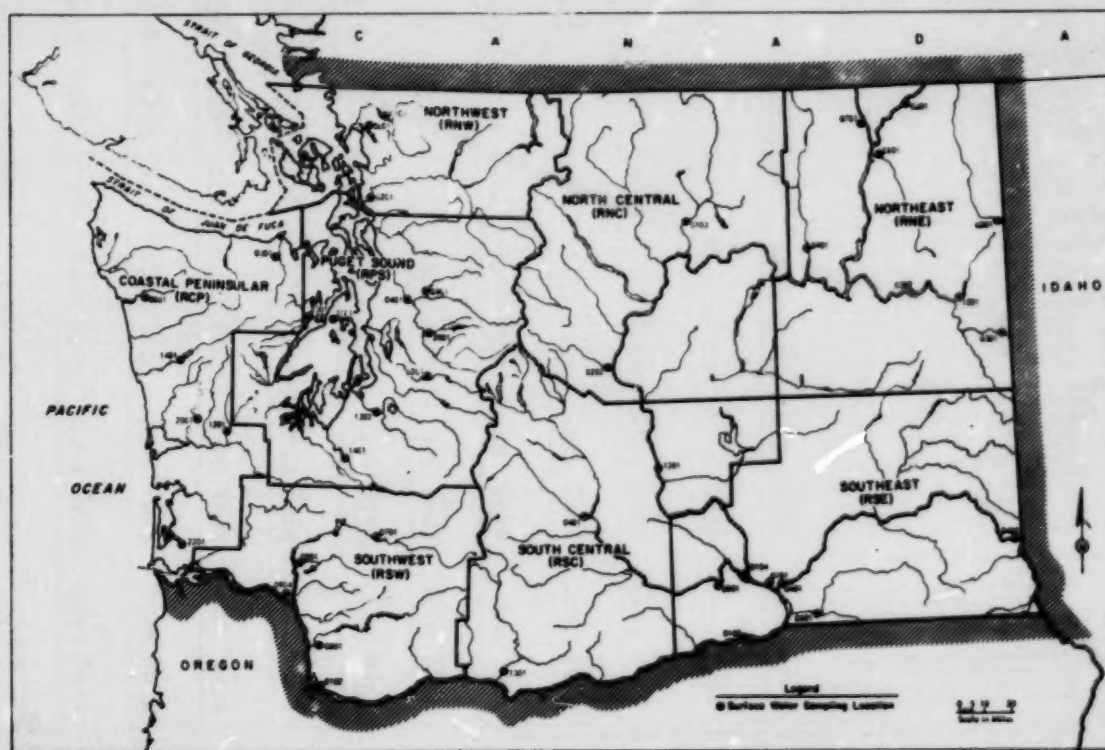


Figure 1. Washington surface water sampling locations with code numbers

Table 2. Monthly average radioactivity in Columbia River water, July 1966-June 1967

Location and type of analysis	Concentration (pCi/liter)											
	1966						1967					
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
McNary Dam (code no. RSE 0102)												
Beta-particle												
Suspended *	NB	NB	8	NB	NB	8	NB	14	NB	NB	11	NB
Dissolved *	NB	NB	30	NB	NB	70	NB	76	NB	NB	22	NB
Total *	NB	NB	38	NB	NB	78	NB	90	NB	NB	33	NB
Phosphorus-32 *	NB	NB	36	NB	NB	84	NB	108	NB	NB	25	NB
Gamma-ray *												
Chromium-51	NB	NB	2,091	NB	NB	2,935	NB	3,356	NB	NB	532	NB
Ruthenium-106 *	NB	NB	<50	NB	NB	<50	NB	67	NB	NB	<50	NB
Zirconium-95	NB	NB	<10	NB	NB	<10	NB	<5	NB	NB	<5	NB
Zinc-65	NB	NB	<25	NB	NB	115	NB	174	NB	NB	69	NB
Northport (code no. RNE 0801)												
Beta-particle												
Suspended *	NB	NB	<1	NB	NB	<1	NB	<1	NB	NB	NB	1
Dissolved *	NB	NB	3	NB	NB	3	NB	3	NB	NB	NB	3
Total *	NB	NB	<4	NB	NB	<4	NB	<4	NB	NB	NB	4
Phosphorus-32 *	NB	NB	<1	NB	NB	<1	NB	<1	NB	NB	NB	<1
Gamma-ray *												
Chromium-51	NB	NB	<100	NB	NB	<100	NB	<100	NB	NB	NB	<100
Ruthenium-106 *	NB	NB	<50	NB	NB	<50	NB	<50	NB	NB	NB	<50
Zirconium-95	NB	NB	<10	NB	NB	<10	NB	<5	NB	NB	NB	<5
Zinc-65	NB	NB	<25	NB	NB	<20	NB	<20	NB	NB	NB	<20
Richland (code no. RSE 0104)												
Beta-particle												
Suspended *	4	17	34	32	1	30	22	24	14	26	58	29
Dissolved *	30	15	121	164	61	195	211	150	222	282	242	63
Total *	34	32	145	196	62	215	233	174	236	308	300	91
Phosphorus-32 *	27	4	148	123	67	176	254	198	232	300	288	74
Gamma-ray *												
Chromium-51	<779	<200	5,740	8,458	3,914	5,197	7,322	7,681	6,472	7,284	5,652	1,539
Ruthenium-106 *	<100	<100	<100	<144	<100	<115	<100	<111	104	111	127	<100
Zirconium-95	<20	<20	<20	<20	<20	<20	<10	<10	<10	<10	<10	<10
Zinc-65	<75	143	173	278	100	299	352	408	339	466	445	198
Pasco (code no. RSE 0101)												
Beta-particle												
Suspended *	12	1	46	36	37	54	27	34	23	30	47	15
Dissolved *	40	5	99	96	51	123	117	170	108	144	103	26
Total *	52	6	145	112	88	177	144	204	131	174	150	41
Phosphorus-32 *	54	NA	95	61	30	115	147	201	121	183	219	29
Gamma-ray *												
Chromium-51	1,137	<100	6,723	5,027	4,549	6,118	3,592	6,875	4,918	3,777	4,678	815
Ruthenium-106 *	<50	<50	90	37	<50	<50	57	103	95	84	98	<50
Zirconium-95	<10	<10	<10	<10	<10	<5	<5	<5	<5	<5	<5	<5
Zinc-65	81	<25	149	114	157	191	242	348	282	273	343	90
Wanapum Dam (code no. RSC 1201)												
Beta-particle												
Suspended *	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved *	2	3	3	3	3	3	3	3	3	3	2	3
Total *	<3	<4	<4	<4	<4	<4	<4	<4	<4	<4	<3	<4
Phosphorus-32 *	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Gamma-ray *												
Chromium-51	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Ruthenium-106 *	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Zirconium-95	<10	<10	<10	<10	<10	<10	<5	<5	<5	<5	<5	<5
Zinc-65	<25	<25	<25	<25	<25	<20	<20	<20	<20	<20	<20	<20
Vancouver (code no. RSW 0103)												
Beta-particle												
Suspended *	6	1	3	6	4	7	30	13	10	27	25	13
Dissolved *	10	4	12	34	26	30	34	32	35	41	44	19
Total *	16	5	15	30	30	37	54	45	45	68	72	32
Phosphorus-32 *	9	<1	5	21	26	35	38	34	38	44	56	21
Gamma-ray *												
Chromium-51	<332	<100	926	1,788	1,568	1,749	1,879	1,409	1,738	1,471	1,823	806
Ruthenium-106 *	<50	<50	<50	<50	<50	<50	<55	<50	<50	<50	<50	<51
Zirconium-95	<10	<10	<10	<10	<10	<10	<5	<5	<5	<5	<5	<5
Zinc-65	<37	<25	<25	<25	21	32	51	68	70	80	104	48
Longview (code no. RSW 0804)												
Beta-particle												
Suspended *	4	1	2	4	3	NB	5	3	5	7	12	5
Dissolved *	10	4	8	17	16	NB	15	8	15	17	20	11
Total *	14	5	10	21	19	NB	20	11	20	24	32	16
Phosphorus-32 *	9	<1	4	14	15	NB	15	9	15	20	23	12
Gamma-ray *												
Chromium-51	<460	<100	<617	1,090	1,211	NB	888	324	704	667	746	339
Ruthenium-106 *	<50	<50	<50	<50	<50	NB	<50	<50	<50	<50	<50	<50
Zirconium-95	<10	<10	<10	<10	<10	NB	<5	<5	<5	<5	<5	<5
Zinc-65	<25	<25	<25	<25	<25	NB	<20	<20	33	36	53	22

* Activity at time of counting. Strontium-90-yttrium-90 calibration standard.

* Results extrapolated to date of sample collection.

* Net activity in the 0.44-0.56 MeV gamma-range is assumed to be only ruthenium-106.

NB, no sample reported.

NA, no analysis.

Table 3. Beta radioactivity in Washington surface water (except for Columbia River)
July 1966-June 1967

Sampling location	Code number	Number of samples	Concentrations (pCi/liter)								
			Suspended			Dissolved			Total		
			Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum
Cedar River.....	RPS 0201	12	<1	<1	<1	<1	<1	1	1	1	2
Chico Creek.....	RPS 3101	1	<1			2			3		
Colville River.....	RNE 0801	3	1	<1	2	5	4	5	6	5	7
Cowlitz River.....	RSW 0701	1	<1			1			2		
Dosewallips River.....	RPS 2301	1	<1			<1			1		
Dungeness River.....	RCP 0301	1	<1			<1			1		
Hoh River.....	RCP 0801	1	<1						3		
Kettle River.....	RNE 0701	3	<1	<1	<1	2	2	2	3	3	3
Klickitat River.....	RCS 1301	8	<1	<1	1	2	1	2	3	2	3
Lake Whatcom.....	RNW 0601	11	<1	<1	2	3	2	4	4	3	5
Lewis River.....	RSW 0801	11	<1	<1	2	<1	<1	2	1	1	4
Little Spokane River.....	RNE 1001	2	<1	<1	<1	3	2	3	4	3	4
Naches River.....	RBC 0401	12	<1	<1	<1	1	<1	2	2	1	3
Naselle River.....	RCP 2201	11	<1	<1	3	<1	<1	3	3	1	4
Nisqually River.....	RPS 1401	4	<1	<1	1	2	1	3	2	2	3
Nookach River.....	RNC 0101	4	<1	<1	<1	3	2	4	4	3	6
Okanogan River.....	RNC 0103	5	<1	<1	3	3	2	4	3	3	6
Pond Oreille River.....	RNE 0201	7	<1	<1	<1	2	2	3	3	3	4
Puyallup River.....	RPS 1302	11	2	<1	7	2	1	5	4	2	10
Quinalt River.....	RCP 1401	1	<1			<1			1		
Sanpoil River.....	RNE 0901	1	<1			2			3		
Sateop River.....	RCP 1201	4	3	<1	10	<1	<1	1	4	1	11
Skagit River.....	RNW 0201	12	<1	<1	<1	2	1	3	3	2	4
Snake River.....	RSE 0401	3	1	<1	2	4	2	5	5	4	6
	RSE 0402	4	5	<1	17	6	3	9	11	5	26
Stechomiah River.....	RPS 0401	4	<1	<1	<1	1	1	2	2	2	3
Spokane River.....	RNE 0301	1	<1			1			2		
	RNE 0302	3	<1	<1	<1	3	2	4	4	3	5
Sultan River.....	RPS 0901	3	<1	<1	<1	2	2	2	3	3	3
Tolt River.....	RPS 3001	4	<1	<1	<1	1	1	2	2	2	3
Toutle River.....	RSW 0201	4	<1	<1	<1	1	1	2	2	2	3
Walla Walla River.....	RSE 0501	3	2	<1	3	3	3	10	7	5	11
Wenatchee River.....	RNC 0202	3	<1	<1	<1	2	2	2	3	3	3
Wishkah River.....	RCP 2001	10	<1	<1	<1	<1	<1	1	1	1	2
Yakima River.....	RCS 0301	5	<1	<1	<1	<1	<1	1	1	1	2
Network summary.....		175	<1	<1	17	1.8	<1	10	3.0	1	26

* For averaging purposes, <1 is assumed to be equal to 0.5 pCi/liter. Averages less than 1 are recorded as <1.
 † One analysis voided, not included in average.

Discussion

Of the 175 river water samples analyzed from July 1966 through June 1967 (excluding the Columbia River) the total beta radioactivity ranged from 1 to 26 pCi/liter with an average of 3.0 pCi/liter. The radioactivity of the suspended fraction ranged from <1 to 17 pCi/liter with an average of <1 pCi/liter. The radioactivity of the soluble fraction was approximately the same, ranging from <1 to 10 pCi/liter and averaging 1.8 pCi/liter. These network averages during the July 1966 through June 1967 period were lower than the averages for the preceding 12 months.

Monthly average total beta radioactivity for the Columbia River stations below the Hanford facility ranged from 5 to 308 pCi/liter. Monthly average concentrations of the beta-particle emitter, phosphorus-32, in the Columbia River water samples taken below the Hanford facility ranged from <1 to 360 pCi/liter.

The gamma-ray emitters, ruthenium-106 and zirconium-95, were found in monthly average concentrations that ranged from <50 to 127 pCi/liter for ruthenium-106 and <5 to <20 pCi/liter for zirconium-95. The values for ruthenium-106 were probably a combination of ruthenium-103 and ruthenium-106. Two other radionuclides, chromium-51 and zinc-65, were found in detectable quantities in Columbia River water. Monthly averages for chromium-51 ranged from <100 to 8,458 pCi/liter, and for zinc-65 the range was <20 to 466 pCi/liter.

Although any standards for gross beta radioactivity must be very carefully applied, the standard for drinking water is 1,000 pCi/liter of gross beta radioactivity in the absence of strontium-90 and alpha emitters (5). The standards for water from all dietary sources for the general population at large (6) are:

chromium-51, 670,000 pCi/liter; ruthenium-106, 3,300 pCi/liter; zinc-65, 10,000 pCi/liter; and phosphorus-32, 7,000 pCi/liter.

Table 4. Gamma radioactivity in Washington surface water

Date	Location	(cpm/liter)
9/24/66	Little Spokane River	8
1/4/67	Puyallup River	7
1/5/67	Snake River	14
4/23/67	Pend Oreille River	12
4/24/67	Cedar River	9
5/23/67	Cedar River	10

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July 1964-June 1965	May 1966
July 1965-June 1966	August 1967

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Drinking Water Analysis Program, 1961-1966¹

*Water Supply and Sea Resources Program
National Center for Urban and Industrial
Health and National Center for
Radiological Health*

The routine surveillance of finished drinking water from public drinking water supplies has been a project of the Public Health Service's Water Supply and Sea Resources Program² since 1960. Since that time over three hundred community water supplies have been examined for selected parameters of radioactivity. The basic network for this activity is the approximately 800 water supplies (serving over half of the nation's population with access to public water systems) which provide water for use by Interstate Carrier Companies. These water supplies are subject to the provisions of Subpart J of the Interstate Quarantine Regulation most commonly referred to as the Public Health

Service drinking water standards. The project for surveillance of the radioactivity levels has been incorporated into the normal survey activities associated with application of the drinking water standards. Laboratory support is provided by the Northeastern, Southeastern and Southwestern Radiological Health Laboratories of the National Center for Radiological Health. Sampling has been conducted as a secondary part of the overall application of the standards and has not been by nationwide design. For the most part, samples have been composited over a fourteen day period taking 90 milliliters, three times during the operating day; however, as indicated in table 1, many samples have also been taken at one point in time. In many cases where a water system receives raw water from more than one source the finished drinking water derived from each source has been examined.

¹ Summarized from "Drinking Water Quality of Selected Interstate Carrier Water Supplies, 1962-1963," U.S. Public Health Service, PHS Publication No. 1049-A.

² Formerly Water Supply Section, Division of Environmental Engineering and Food Protection.

Table 1. Occurrence of radioactivity concentrations in finished drinking water (pCi/liter) 1961-1966

Sampling location	Sampling periods	Strontium-90 in total solids	Alpha radioactivity		Beta radioactivity	
			Dissolved	Suspended	Dissolved	Suspended
Ala:	Birmingham.....	10/4-10/18/61	—	—	3.7	<3.0
		5/4-5/19/62	—	—	8.8	<3.0
		10/4-10/18/61	—	—	<3.0	<3.0
		5/2-5/18/62	—	—	5.2	<3.0
	Gadsden.....	9/25-10/10/61	1.8	—	3.4	<3.0
		3/14-3/28/62	—	—	14.0	<3.0
	Mobile.....	11/16-12/2/61	—	—	6.3	<3.0
		5/1-5/15/62	—	—	14.0	<3.0
	Montgomery.....	5/30-6/12/61	<.5	<.5	<3.0	<3.0
		5/31-6/15/61	<.5	<.5	<3.0	<3.0
Tuscaloosa.....		5/7-6/22/61	1.1	—	37.0	<3.0
		5/30-6/6/66	—	0.0	3.1	<3.0
Alaska:	Kodiak.....	4/8-4/18/65	—	<.1	<1.0	5.0
Ariz:	Phoenix.....	7/25-8/8/61	<.5	<.5	<1.0	<1.0
		7/25-8/8/61	<.5	<.5	<3.0	<1.0
		7/25-8/8/61	<.5	<.5	6.3	<1.0
		7/25-8/8/61	<.5	<.5	6.2	<1.0
		7/25-8/8/61	<.5	<.5	6.2	<1.0
	Tucson.....	6/8-6/21/61	3.5	<.5	5.0	<1.0
Calif:	Fresno.....	10/2-10/18/61	—	—	3.5	3.3
	Needles.....	7/18-8/4/61	<.5	<.5	3.2	<1.0
Colo:	Durango.....	6/6-6/22/65	—	0.8	0.2	3.0
Conn:	Groton.....	9/24-9/28/66	—	—	—	—
	Hartford.....	4/26-5/10/61	<5.0	<5.0	<3.0	<3.0
		12/5-12/18/62	<1.0	<1.0	4.0	1.0
	New Haven.....	2/25-3/11/62	<1.0	<1.0	5.0	<1.0
	New London.....	9/15-9/30/66	—	—	—	—
Del:	Waterbury.....	—	<1.0	<1.0	5.0	<1.0
	Clayton.....	10.0	2.6	<1.0	13.0	2.0
	Lewes.....	6/19-8/23/64	<1.0	<1.0	<1.0	<1.0
	Wilmington.....	1965	<1.0	<1.0	3.5	<1.0
	Brandywine.....	2/13-3/1/61	<.5	—	<3.0	—
D. C.:		11/7-11/21/62	—	—	7.2	<3.0
		9/11-9/24/62	<1.0	<1.0	3.0	<1.0
		10/2-10/15/62	<1.0	<1.0	5.0	<1.0
	Washington.....	11/18/66	1.5	<.2	<.2	4.0
Fla:		10/11-10/26/61	—	—	7.5	<3.0
		10/11-10/26/61	—	—	6.1	<3.0
	Ft. Lauderdale.....	4/27-5/11/61	—	<.5	<.5	3.4
		9/19-10/9/62	—	—	3.0	3.0
Ga:		4/27-5/12/61	<.5	<.5	<3.0	<3.0
		9/19-10/3/62	—	—	<3.0	<3.0
	Atlanta.....	8/15-9/1/61	—	<.3	<.3	7.3
		3/13-3/29/62	—	—	<3.0	<3.0
Columbus.....		8/15-8/20/61	—	—	7.9	<3.0
		12/17-1/2/63	—	—	<3.0	<3.0
		11/14-1/28/61	—	—	8.8	<3.0
		1/10-1/28/63	—	—	4.5	<3.0
Savannah.....		11/28-12/14/61	—	—	11.8	<3.0
		8/2-8/16/62	—	—	13.0	<3.0
		8/2-8/16/62	—	—	5.9	3.0
Ill:		8/2-8/16/62	—	—	<3.0	<3.0
	Alton.....	5/19-6/2/66	—	<1.0	<1.0	8.0
	Beardstown.....	3/24-4/6/64	<1.0	<1.0	<1.0	2.0
	Cairo.....	2/16-3/13/61	0.3	12.0	—	2.6
		6/29-7/13/62	<1.0	<1.0	<1.0	<1.6
	Chester.....	2/15-3/2/61	0.7	<.5	—	3.6
	Danville.....	9/15-9/29/64	—	1.0	<1.0	6.0
	Decatur.....	7/11-7/26/61	—	—	<3.0	<3.0
		5/30-6/4/66	—	<1.0	<1.0	5.0
	E. St. Louis.....	2/14-2/28/61	0.9	<.5	—	3.3
	Joliet.....	10/12-10/25/66	0.0	3.0	<1.0	10.0
	Lockport.....	10/20-11/3/64	—	4.0	<1.0	3.0
	Moline Airport.....	9/22-10/6/64	—	<1.0	<1.0	4.0
	Orland Park.....	1965	—	<1.0	<1.0	3.0
	Peoria.....	6/28-7/12/66	2.0	<1.0	<1.0	11.0
	Peru.....	9/28-11/8/65	2.0	3.0	<1.0	18.0
	Quincy Airport.....	1964	<1.0	<1.0	<1.0	2.0
	Rockford.....	1965	—	<1.0	<1.0	2.0
	Rock Island.....	7/12-7/26/61	—	<.5	<.5	3.6
	Springfield.....	5/4-5/18/65	—	4.0	<1.0	<1.0
	Wood River.....	5/27-6/8/66	—	1.0	<1.0	3.0
Ind:	Elkhart.....	6/16-6/30/61	—	<.5	<.5	<3.0
		3/19-3/5/62	—	<.5	<.5	<3.0
	Evansville.....	6/15-6/30/61	—	<.5	<.5	<3.0
		8/6-8/21/62	<1.0	<1.0	4.0	<1.0
	Indianapolis.....	12/13-12/27/66	—	<1.0	<1.0	5.0
White River.....		1/17-2/1/61	0.3	<.5	<.5	3.2
		5/16-5/30/62	—	—	—	<3.0

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Table 1. Continued.

Sampling location	Sampling periods	Strontium-90 in total solids	Alpha radioactivity		Beta radioactivity	
			Dissolved	Suspended	Dissolved	Suspended
Fall Creek.....	1/17-2/1/61	0.3	<.5	<.5	<2.6	<2.6
Lafayette.....	5/14-6/29/62	—	—	—	15.0	<3.0
Muncie.....	1/18-2/1/61	0.2	<.5	<.5	4.0	<3.0
Washington.....	5/24-6/7/62	—	—	—	<2.6	<3.0
	6/13-6/21/61	—	<.5	<.5	19.0	<3.0
	8/8-9/20/62	<1.0	0.0	0.1	<3.0	<3.0
	8/3-8/17/66	—	<1.0	<1.0	0.1	0.0
Iowa: Burlington.....	1/4-1/18/62	—	1.0	—	9.3	.3
Des Moines.....	11/1-11/17/61	—	—	11.4	—	—
Kans: Kansas City.....	11/3-11/30/61	—	6.5	.1	.6	3.6
Ky: Ashland.....	—	—	<.1	<.1	<14.3	3.0
	1/20-2/9/61	.1	<.5	—	<2.6	—
	1/22-2/7/61	—	<.5	—	<2.6	—
	2/19-3/4/64	—	<.1	<.1	6.2	<3.0
	2/19-3/4/64	4.2	<.1	<.1	14.7	<3.0
	Louisville.....	—	<.5	<.5	3.2	<3.0
	Paducah.....	—	—	—	6.8	<1.0
	11/3-11/17/66	—	—	—	22.0	<3.0
	3/7-3/31/63	—	—	—	—	—
La: Alexandria.....	8/8-8/21/61	—	—	—	<3.0	<3.0
	10/24-11/14/62	—	—	—	5.1	<3.0
	8/8-8/31/61	—	—	—	<3.0	<3.0
	9/30-10/30/62	—	—	—	9.4	3.0
	New Orleans.....	—	—	—	—	—
	Carrollton.....	—	—	—	7.3	<3.0
	Shreveport.....	—	—	—	3.9	<3.0
	—	—	—	—	4.0	<3.0
	—	—	—	—	<3.0	<3.0
	—	—	—	—	4.4	<3.0
	—	—	—	—	8.8	<3.0
Maine: Bar Harbor.....	5/15-5/29/64	5.0	<1.0	<1.0	18.0	3.0
Portland.....	3/20-4/3/61	—	<.5	<.5	3.9	<3.0
	10/10-10/24/62	<1.0	<1.0	<1.0	7.0	<1.0
	—	2.0	<1.0	<1.0	12.0	2.0
	—	3.0	<1.0	<1.0	12.0	7.0
	—	—	<1.0	<1.0	2.0	<1.0
Md: Baltimore.....	10/30-11/13/61	—	—	—	4.6	<3.0
	6/13-6/26/63	—	—	—	8.7	<3.0
	10/27-11/10/61	—	—	—	6.8	<3.0
	Hagerstown.....	—	—	—	6.0	<3.0
	—	—	—	—	10.0	<3.0
	—	—	—	—	8.8	<3.0
Mass: Fall River.....	11/23-12/7/64	—	2.0	<1.0	7.0	2.0
Lowell.....	3/16-3/30/61	—	<.5	<.5	<3.0	<3.0
	2/5-2/18/63	<1.0	<1.0	<1.0	3.0	<1.0
	Springfield.....	1.5	<1.0	<1.0	11.0	<1.0
	Worcester.....	—	<1.0	<1.0	3.0	<1.0
Mich: Ann Arbor.....	4/20-5/6/61	—	<.5	<.5	<3.0	<3.0
	9/10-10/3/62	<1.0	<1.0	<1.0	3.0	<1.0
	Bay City.....	—	—	—	4.4	<3.0
	—	2.4	—	—	16.0	<3.0
	Calumet.....	—	1.0	<1.0	2.0	<1.0
	Detroit.....	—	—	—	—	—
	Park.....	7/29-8/13/64	<1.0	<1.0	3.0	5.0
	Northwest.....	8/3-8/17/64	<1.0	<1.0	4.0	<1.0
	Southwest.....	8/18-8/31/64	<1.0	<1.0	6.0	2.0
	Spring.....	—	—	—	—	—
	Wells.....	8/19-9/2/64	<1.0	<1.0	3.0	<1.0
	East China.....	6/17-6/30/66	<1.0	<1.0	5.0	<1.0
	Habor Springs.....	6/20-7/3/66	<1.0	<1.0	1.0	<1.0
	Freeland.....	6/16-6/30/66	2.0	<1.0	1.0	<1.0
	Houghton.....	—	<1.0	<1.0	<1.0	<1.0
	Ishpeming.....	—	<1.0	<1.0	8.0	<1.0
	Mackinac.....	6/27-7/10/66	<1.0	<1.0	<1.0	<1.0
	Monroe.....	4/19-5/3/61	<1.0	<1.0	4.6	<3.0
	—	9/17-10/2/62	<1.0	<1.0	3.0	<1.0
	—	9/12-9/27/61	<1.0	<1.0	7.6	<3.0
	—	4/6-4/23/62	<1.0	—	7.3	<3.0
	—	4/21-5/5/61	<.5	<.5	2.9	<3.0
	—	9/17-9/30/62	<1.0	<1.0	4.0	2.0
	—	10/24-11/7/66	<1.0	<1.0	5.0	2.0
	—	9/13-9/29/61	—	—	5.4	<3.0
	—	6/28-7/11/66	<1.0	<1.0	4.0	<1.0
	—	8/26-9/9/64	<1.0	<1.0	4.0	<1.0
	—	8/27-9/9/64	<1.0	<1.0	3.0	<1.0
Minn: Duluth.....	7/21-8/11/61	—	<.5	<.5	2.0	<1.0
Miss: Greenville.....	1/12-1/27/61	.5	<.5	<.5	<2.6	<2.6
	10/25-11/9/62	—	—	—	<3.0	<3.0
	Jackson.....	6/1-6/15/61	<.5	<.5	<3.0	<3.0
	Vicksburg.....	2/15-3/2/61	<.5	—	4.3	<3.0
	—	8/13-8/28/62	—	—	11.4	<3.0

Table 1. Continued.

Sampling location	Sampling periods	Strontium-90 in total solids	Alpha radioactivity		Beta radioactivity	
			Dissolved	Suspended	Dissolved	Suspended
Mont: E. Glacier	1965	—	<.1	<.1	2.0	<1.0
Havre	1965	—	.3	.1	13.0	<1.0
Nebr. Lincoln	10/34-11/3/61	—	—	—	19.6	1.2
N. Platte	10/34-11/7/61	—	11.4	.3	14.1	.3
N. H: Berlin	5/1-5/13/61	—	<.5	<.5	<1.0	<3.0
Manchester	10/15-10/30/62	<1.0	<1.0	<1.0	6.0	<1.0
	5/3-5/17/61	—	<.5	<.5	4.4	<3.0
	10/20-11/2/62	<1.0	<1.0	<1.0	8.0	1.0
	6/1-6/14/66	—	<1.0	<1.0	12.0	<1.0
N. J: Atlantic City	7/15-7/30/64	—	<1.0	<1.0	5.0	2.0
Elizabeth Water Co.	5/13-5/27/65	1.0	<1.0	7.0	2.0	35.0
Hackensack Water Co.	9/4-9/18/64	—	<1.0	<1.0	<1.0	1.0
Jersey City	10/25-11/3/64	—	5.0	<1.0	7.0	<1.0
Newark	10/25-11/6/64	—	<1.0	<1.0	6.0	<1.0
Ocean City	9/1-9/14/64	—	<1.0	<1.0	2.0	<1.0
Trenton	10/2-10/16/61	—	—	—	10.0	<3.0
	10/10-10/25/62	<1.0	<1.0	<1.0	4.0	<1.0
Wanaque	1964	—	2.0	<1.0	2.0	<1.0
N. Mex: Albuquerque	6/6-6/21/61	—	3.3	<.5	4.3	<1.0
Farmington	8/2-8/17/62	—	—	—	<3.0	3.3
	8/6-8/21/62	—	—	—	4.3	<3.0
	6/7-7/23/61	—	.1	.3	10.0	<1.0
N. Y: Albany	9/27-10/5/61	—	—	—	<3.0	<3.0
	3/27-4/9/62	2.0	—	—	14.0	<3.0
Buffalo	9/29-10/13/61	—	—	—	3.3	<3.0
	9/4-9/18/62	<1.0	<.0	.1	3.3	.4
	5/10-5/21/66	—	<1.0	<1.0	5.0	<1.0
Croton	11/14-11/26/61	—	—	—	11.0	5.0
Catskill	10/24-11/8/61	—	—	—	3.7	<3.0
Jamaica	10/16-11/3/61	—	—	—	3.4	<3.0
Woodhaven Water Co.	10/30-11/14/61	—	—	—	3.2	<3.0
	3/2-3/10/62	—	—	—	<3.0	<3.0
Poughkeepsie	9/12-9/26/61	—	—	—	3.4	<3.0
	—	<1.0	<1.0	<1.0	8.0	<1.0
Ramapo	2/16-3/4/65	—	2.0	<1.0	6.0	<1.0
Roseton	9/17-10/1/62	—	<1.0	<1.0	5.0	<1.0
Rochester	9/12-9/27/61	3.3	—	—	3.7	<3.0
	8/29-9/12/62	<1.0	<1.0	<1.0	6.0	4.0
	9/13-9/26/61	—	—	—	5.4	<3.0
	8/20-9/13/62	<1.0	.1	.1	2.3	<3.0
	9/14-9/27/61	<1.0	—	—	4.6	<3.0
	8/30-9/15/62	<1.0	<1.0	<1.0	1.0	<1.0
Schenectady	9/28-10/10/61	—	—	—	<3.0	—
	3/23-4/5/62	—	—	—	<3.0	<3.0
Troy	1/27-10/12/61	—	—	—	<3.0	<3.0
	4/11-4/28/62	<1.0	—	—	18.0	4.0
White Plains	9/11-9/23/64	—	<1.0	<1.0	4.0	<1.0
Yonkers:						
Grassy Spring Supply	11/5-12/15/64	2.0	2.0	<1.0	19.0	2.0
Saw Mill Supply	11/6-11/30/64	4.0	<1.0	<1.0	11.0	<1.0
N. C: Charlotte	3/30-4/14/61	<1.0	<.5	<.5	<3.0	<3.0
Fayetteville	3/30-4/14/61	<1.0	<.5	<.5	<3.0	<3.0
Raleigh	4/10-4/24/61	<1.0	<.5	<.5	<3.0	<3.0
	3/23-4/5/62	1.6	—	—	19.0	<3.0
Winston-Salem	2/14-3/1/61	.2	<.5	—	<3.6	—
N. Dak: Bismarck	7/18-8/5/61	—	<.5	<.5	6.6	<1.0
Grand Forks	11/9-12/1/61	—	6.4	1.1	12.5	.5
Williston	8/20-9/13/61	—	14.4	1.1	12.8	.7
Ohio: Akron	8/18-9/1/61	—	—	—	<3.0	3.6
	2/19-3/4/62	—	—	—	15.0	<3.0
	5/19-5/24/65	—	<1.0	4.0	4.0	<1.0
Cincinnati	3/13-3/29/61	—	<.5	<.5	<3.0	<3.0
	8/6-8/20/62	<1.0	<1.0	<1.0	<3.0	<1.0
	4/18-5/1/66	—	2.0	<1.0	5.0	<1.0
Cleveland	1965	—	<1.0	<1.0	4.0	<1.0
Columbus	4/18-5/3/66	—	<1.0	<1.0	4.0	1.0
Crestline	7/7-7/30/64	<1.0	<1.0	<1.0	1.0	<1.0
Huron	5/27-6/10/64	<1.1	<1.0	<1.0	3.0	<1.0
Lima	3/16-3/30/61	—	<.5	<.5	4.6	<3.0
	8/6-8/20/62	<1.0	<1.0	<1.0	5.4	<1.0
Lorain	5/10-5/24/65	—	<1.0	2.0	4.0	<1.0
Marion	7/6-7/23/65	<1.0	<1.0	<1.0	7.0	<1.0
Mt. Vernon	—	<1.0	<1.0	<1.0	7.0	<1.0
Sandusky	5/26-6/9/64	<1.0	<1.0	<1.0	8.0	<1.0
Springfield	2/15-3/30/61	—	<.5	<.5	<3.0	<3.0
	8/6-8/20/62	<1.0	.0	.1	.8	.6
Toledo	8/17-9/3/61	—	—	—	<3.0	<3.0
	2/19-3/7/62	—	—	—	5.1	3.0
	4/19-5/3/65	—	<1.0	<1.0	3.0	1.0
Wellsville	7/9-7/23/64	<1.0	<1.0	<1.0	4.0	1.0
Willard	9/26-10/13/66	—	1.0	<1.0	1.0	<1.0
Youngstown	7/9-7/25/64	5.0	<1.0	<1.0	10.0	<1.0

Table 1. Continued.

Sampling location	Sampling periods	Strontium-90 in total solids	Alpha radioactivity		Beta radioactivity	
			Dissolved	Suspended	Dissolved	Suspended
Ohio:						
Arcadia.....	2/3-2/25/61	0.7	<.5		<2.6	
Oakdale City.....	6/25-6/25/61	—	<.5		6.3	<3.0
	2/3-2/25/61	1.2	8.0		5.7	
	2/3-6/17/62	—	—		13.0	<3.0
	4/26-6/14/63	—	—		13.0	<3.0
Ore:						
Astoria.....	10/26-11/9/64	—	3.1	10.2	3.0	<1.0
Bead.....	7/26-8/9/64	—	.5	<.1	<1.0	<1.0
Cade Bay.....	11/10-11/24/64	—	.7	<.1	6.0	<1.0
Eugene.....	10/24-11/9/61	—	—	—	1.4	<1.0
	7/24-8/5/64	—	<.1	<.1	4.0	<1.0
	7/17-7/29/64	—	.1	<.1	9.0	<1.0
Florance.....	7/26-8/11/64	—	.1	<.1	3.0	<1.0
Klamath Falls.....	7/26-8/12/64	—	<.6	<.1	1.0	<1.0
Medford.....	7/17-7/31/64	—	<.1	1.3	<1.0	<1.0
Newport.....	7/22-8/4/64	—	<.1	.1	3.0	<1.0
Portland.....	7/21-8/3/64	—	.8	—	—	—
Reider.....	—	—	—	—	—	—
Pa:						
Allentown.....	6/10-6/15/61	—	<.5	<.5	<3.0	<3.0
	11/28-12/13/62	<1.0	<1.0	<1.0	1.0	<1.0
	7/5-7/19/63	—	<1.0	<1.0	4.0	5.0
Bethlehem.....	3/26-4/5/65	—	<1.0	<1.0	2.0	<1.0
Brownsville.....	3/24-4/3/65	—	<1.0	<1.0	2.0	<1.0
Charlottesville.....	3/24-4/3/65	—	<1.0	<1.0	1.0	<1.0
Corcoran.....	3/22-4/3/65	—	<1.0	<1.0	1.0	<1.0
Elizabethtown.....	7/12-7/24/66	—	<1.0	<1.0	3.3	<1.0
Harrisburg.....	7/12-7/27/61	—	<1.0	<1.0	9.0	<1.0
Lancaster.....	1/7-1/22/66	<1.0	<1.0	—	<3.0	<3.0
	8/26-9/12/61	—	—	—	3.1	<1.0
	8/3-8/25/61	—	—	—	8.5	<3.0
Philadelphia.....	15/21-1/6/62	—	—	—	11.0	<3.0
	7/25-8/6/61	—	—	—	14.0	<3.0
	12/21-1/4/63	—	—	—	<3.0	<3.0
	8/7-8/25/61	—	—	—	13.0	<1.0
	12/21-1/6/62	—	—	<.5	<3.6	<3.0
	1/30-2/14/61	—	—	—	11.0	<3.0
	12/26-1/4/63	—	<1.0	<1.0	4.0	<1.0
Pittsburgh.....	3/26-4/5/65	—	<1.0	<1.0	6.0	<1.0
Reading.....	—	—	<1.0	<1.0	<3.0	<3.0
Rayre.....	6/2-6/16/61	—	<1.0	<1.0	<3.0	<3.0
	9/4-9/23/63	<1.0	<1.0	<1.0	<3.0	<3.0
Puerto Rico:						
San Juan.....	3/15-4/5/63	2.2	—	—	10.0	<3.0
	3/14-3/29/63	1.1	—	—	7.3	<3.0
R. I:						
E. Providence.....	11/13-11/25/64	—	3.6	<1.0	7.0	<1.0
Water Treatment Plant	11/13-11/20/64	—	<1.0	<1.0	1.0	<1.0
Well #1.....	3/27-4/10/61	—	<1.0	<1.0	<3.0	<1.0
Providence.....	4/21-5/5/66	—	<1.0	<1.0	4.0	<1.0
S. C:						
Charleston.....	1/10-1/25/61	—	—	—	<3.0	<3.0
	2/11-2/25/63	—	—	—	14.8	<3.0
	2/10-2/2/61	0.2	<.5	—	<3.0	<3.0
Groesville.....	2/7-2/22/63	—	—	—	9.4	<3.0
N. Augusta.....	9/4-9/1/61	—	—	—	<3.0	<3.0
S. Dak:						
Aberdeen.....	8/28-9/12/61	—	—	9.4	15.3	3.5
Sioux Falls.....	9/1-9/15/61	—	19.9	9.0	9.1	1.1
	2/21-3/9/63	—	—	—	8.0	1.0
Tenn:						
Chattanooga.....	7/12-7/22/61	3.2	—	—	45.0	<3.0
	1/25-3/12/63	—	<.5	<.5	14.0	<3.0
Clarksville.....	7/6-7/24/61	—	<.5	<.5	<3.0	<3.0
Clarksville.....	2/3-2/18/63	—	—	—	8.4	<3.0
Knoxville.....	8/18-9/1/61	—	<.5	<.5	<3.0	<3.0
	2/6-2/20/63	—	<.5	<.5	7.8	<3.0
Nashville.....	—	—	<.5	<.5	6.7	<3.0
Tex:						
Austin Filter Plant #3.....	2/25-3/10/64	<.5	<.1	<.1	11.8	<3.0
Brown Co.....	4/24-5/9/61	<1.0	<.5	<.5	7.0	<3.0
	1/15-1/31/62	—	<.5	<.5	11.1	<3.0
Brownsville.....	2/30-4/13/61	—	<.5	<.5	5.0	<3.0
	3/9-3/23/62	—	<.5	<.5	8.3	<3.0
	2/29-4/12/61	<1.0	<.5	<.5	3.1	<3.0
	3/9-3/23/62	—	<.5	<.5	8.6	<3.0
	3/26-4/12/61	—	<.5	<.5	8.6	<3.0
Corpus Christi.....	4/5-4/19/61	<1.0	<.5	<.5	6.3	<3.0
Dallas.....	8/18-9/2/64	4.4	—	—	11.0	<3.0
Denison.....	—	6.2	<.5	<.5	22.4	<3.0
Galena Park.....	—	—	<.5	<.5	3.3	<3.0
	—	—	<.5	<.5	<3.0	<3.0
	—	—	<.5	<.5	4.3	<3.0
	—	—	<.5	<.5	<3.0	<3.0
Galveston.....	7/18-8/3/61	—	<.5	<.5	<3.0	<3.0
Port of Houston.....	—	—	<.5	<.5	4.5	<3.0
Laredo.....	4/26-5/25/61	—	<.5	<.5	19.0	<3.0
	2/1-3/16/63	—	<.5	<.5	12.8	<3.0
Lebbok.....	3/28-3/10/61	6.0	<.5	<.5	15.0	<3.0
Martinez.....	1964	—	<.1	<.1	<9.0	<3.0
Palentine.....	—	—	<.1	<.1	<9.0	<3.0
(McPee R. R.).....	1964	—	<.1	<.1	<9.0	<3.0

Table 1. Continued.

Sampling location	Sampling periods	Strontium-90 in total solids	Alpha radioactivity		Beta radioactivity	
			Dissolved	Suspended	Dissolved	Suspended
Port Arthur.....	7/10-8/2/61	—	—	—	2.5	<3.0
	8/14-8/18/62	—	—	—	25.0	<3.0
Port Isabel.....	4/16-4/30/64	5.3	1.2	<.1	30.5	<3.0
San Angelo.....	4/25-5/9/61	—	<.5	<.5	<3.0	<3.0
	5/25-6/9/62	—	—	—	16.0	<3.0
San Antonio.....	3/21-3/10/61	—	<.5	<.5	<3.0	<3.0
Temarkana.....	—	6.6	—	—	16.0	8.0
Waco.....	5/25-6/9/61	—	<.5	<.5	3.5	<3.0
	5/30/6/14/63	—	—	—	21.0	<3.0
Wichita Falls.....	5/25-6/10/61	—	<.5	<.5	5.5	<3.0
	5/25-6/13/62	—	—	—	15.0	<3.0
Vt: Burlington.....	1/11-1/25/61	1.9	<.5	<.5	2.9	<3.5
	12/11-12/29/63	<1.0	<1.0	<1.0	5.0	1.0
St. Albans.....	12/8-12/22/64	—	<1.0	<1.0	9.0	<1.0
Va: Norfolk.....	5/15-5/29/61	—	<.5	<.5	3.5	<3.0
	4/9-4/25/62	—	—	—	21.0	<3.0
	5/16-5/30/61	—	<.5	<.5	<3.0	<3.0
	4/9-4/24/62	1.3	—	—	20.0	<3.0
Portsmouth.....	5/21-6/7/61	—	—	—	10.0	35.0
	3/1-3/17/62	—	—	—	5.1	<3.0
Richmond.....	12/6-12/21/61	—	—	—	10.0	<3.0
	4/18-5/3/63	—	—	—	8.1	<1.0
Wash: Spokane.....	7/26-8/10/61	—	<.5	<.5	5.7	2.3
W. Va: Huntington.....	12/9-12/27/60	.7	—	—	2.2	<1.0
	6/7-6/23/62	—	—	—	6.8	<3.0
Pt. Pleasant.....	5/65	2.4	<.2	<.2	3.3	<3.0
Williamson.....	5/65	1.0	<.2	<.2	5.5	<3.0
Wisc: Greenbay.....	5/16-6/3/61	—	<.5	<.5	<3.0	<3.0
	9/17-10/2/62	<1.0	<1.0	<1.0	3.0	<1.0
	7/19-8/2/63	—	<1.0	<1.0	5.0	<1.0
La Crosse.....	11/24-12/3/64	—	3.0	<1.0	2.0	5.0
Madison.....	7/18-8/1/61	—	—	—	3.8	<3.0
Manitowoc.....	5/17-6/21/61	—	<.5	<.5	<3.0	<3.0
	11/8-11/23/62	<1.0	<1.0	<1.0	2.0	<1.0
Milwaukee.....	6/10-6/25/64	<1.0	<1.0	<1.0	6.0	<1.0
	6/11-6/25/64	<1.0	<1.0	<1.0	4.0	<1.0
Neenah.....	5/15-6/3/61	—	<.5	<.5	2.9	<3.0
	10/19-11/1/62	—	<1.0	<1.0	5.0	<1.0
Wausau.....	6/9-6/23/64	<1.0	<1.0	<1.0	<1.0	<1.0

The drinking water standards for radionuclides are conservative in their requirements so that the total intake of these nuclides from all sources is not likely to result in an intake greater than the guidance levels given by the Federal Radiation Council (2).

The standards provide for the approval of water supplies, based on their radionuclide content, when the water does not contain more than 3 pCi/liter of radium-226 or 10 pCi/liter of strontium-90. In the absence of strontium-90 (much less than 10 pCi/liter), and in the absence of alpha emitters (much less than 3 pCi/liter), the water supply is acceptable when the gross beta concentration does not exceed 1,000 pCi/liter.

However, a water supply may be approved when the limits prescribed above are exceeded if it can be demonstrated by surveillance that the total intake of radioactivity from all sources

is within the guidance recommended by the Federal Radiation Council for control action. When mixtures of radionuclides are present, the relative contribution of each radionuclide to the total intake of the individual should be considered when evaluating the exposure.

Table 1 indicates all analytical determinations as reported by the examining laboratory. Table 2 is a summary of the five types of analysis listed in table 1.

Table 2. Drinking water analysis program, 1961-1966
summary of data

Radioactivity	Number of analyses	Concentration range (pCi/liter)
Strontium-90.....	98	0.0-10.0
Dissolved alpha.....	232	.0-19.9
Suspended alpha.....	222	.0-10.3
Dissolved beta.....	364	.1-45.0
Suspended beta.....	348	.0-35.0

REFERENCES

- (1) DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, PUBLIC HEALTH SERVICE. Federal Register Rules and Regulations, Title 42, Public Health Chapter 1, Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards: 2154-2155 (March 6, 1962).
- (2) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. (September 1961).
- (3) PUBLIC HEALTH SERVICE. Radioactivity in drinking water, 1961. Rad Health Data 3:157-158 (May 1962); 254-255 (August 1962); 411-412 (October 1962); 4:37-39 (January 1963).
- (4) PUBLIC HEALTH SERVICE. Drinking water quality of selected interstate carrier water supplies, 1960-1961. PHS Publication 1049 (June 1963).
- (5) PUBLIC HEALTH SERVICE. Drinking water quality of selected interstate carrier water supplies, 1962-1963, PHS Publication 1049-A (1965).
- (6) PUBLIC HEALTH SERVICE. Water supply data. Unpublished reports prepared by the Water Supply and Sea Resources Program.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of

atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

<u>Network</u>	<u>Period</u>	<u>Issue</u>
HASL Fallout Network	January-June 1967	March 1968
HASL 80th Meridian Network	Calendar year 1965	January 1967

1. Radiation Alert Network April 1968

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They

also perform field estimates on dried precipitation samples and report all results to appropriate National Center for Radiological Health officials by mail or telephone, depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (1). A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique during April 1968. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting stations.

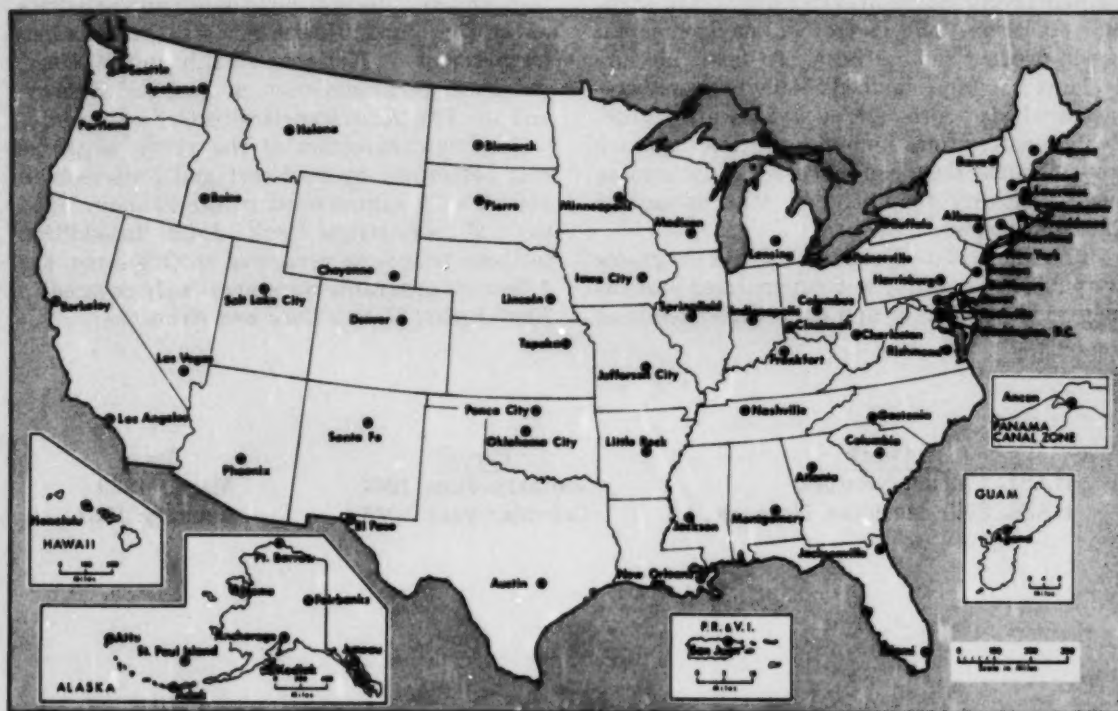


Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, April 1968

Station location	Number of samples		Air surveillance gross beta radioactivity (pCi/m ³)			Last profile in RHD&R	Precipitation				
							Total depth (mm)	Field estimation of deposition ^b			
								Number of samples	Depth (mm)	Total deposition (nCi/m ²)	
Ala:	Montgomery	28	3	4.40	0.45	1.84	Nov 67	68	3	68	7
Alaska:	Adak	4		1.10	.35	.55	Apr 68	(*)			
	Anchorage	28	3	.00	.00	.00	Dec 67	(*)	2	7	0
	Attu Island	(*)					May 68	(*)			
	Fairbanks	20	14	.34	.00	.01	Jan 68	(*)			
	Juneau	29		.89	.00	.31	Feb 68	213	14	213	0
	Kodiak	(*)					Mar 68	(*)			
	Nome	20		1.25	1.08	1.18	July 68	(*)			
	St. Paul Island	30		.44	.43	.44	June 68	(*)			
Aris:	Phoenix	22		0.42	.15	4.25	Feb 68	(*)			
Ark:	Little Rock	6	2	1.25	.31	1.12	Dec 67	(*)	0	0	(*)
Calif:	Berkeley	22	1	.74	.00	.32	Mar 68	(*)	1	9	0
	Los Angeles	22	1	1.93	.37	.97	July 68	(*)	1	10	0
C. S:	Ancon	16		3.65	2.15	2.78	Mar 68	(*)			
Colo:	Denver	21	3	5.09	.60	2.12	Mar 68	(*)	(*)	(*)	0
Conn:	Hartford	30	6	.28	.22	.24	Jan 68	(*)	6	28	0
Del:	Dover	30	6	1.85	.29	.68	Nov 67	(*)	5	22	0
D. C:	Washington	30	6	5.00	.00	1.15	June 68	(*)	0	0	(*)
Fla:	Jacksonville	22	2	3.14	.32	.62	Dec 67	(*)	1	8	0
	Miami	15	1	1.35	.15	.48	Jan 68	(*)			
Ge:	Atlanta	21	8	1.62	.78	1.05	Aug 68	150	0	0	(*)
Guam:	Agaña	12		.52	.17	.37	Nov 67	(*)			
Hawaii:	Honolulu	30	3	.80	.20	.54	May 68	(*)	(*)	(*)	0
Idaho:	Boise	22	2	4.80	1.19	2.98	May 68	(*)	2	16	0
Ill:	Springfield	30	3	4.26	.14	1.75	June 68	(*)	0	0	(*)
Ind:	Indianapolis	18	6	2.82	1.44	1.95	Aug 68	107	5	107	207
Iowa:	Iowa City	31	9	5.08	.75	2.06	Mar 68	(*)	1	14	0
Kans:	Topeka	31	8	3.79	.25	1.35	Dec 67	(*)	8	92	0
Ky:	Frankfort	8	1	1.90	.58	.78	June 68	(*)	1	3	4
La:	New Orleans	21	6	1.99	.32	.70	June 68	(*)	(*)	(*)	0
Maine:	Augusta	21	9	1.31	.00	.65	July 68	(*)	9	85	0
Md:	Baltimore	20	4	1.55	.26	.98	Jan 68	(*)	4	25	11
	Rockville	(*)					May 68	(*)			
Mass:	Lawrence	16	5	1.72	.00	.55	Nov 67	(*)	0	0	(*)
	Worcester	21	7	2.64	.00	.67	Apr 68	(*)	7	45	0
Mich:	Lansing	11	5	2.38	.75	1.32	May 68	(*)	5	19	72
Minn:	Minneapolis	21	7	.85	.16	.29	Nov 67	(*)	7	88	92
Miss:	Jackson	16	5	1.64	.54	.89	July 68	(*)	3	27	63
Mo:	Jefferson City	21	7	2.52	.35	1.05	Aug 68	(*)	7	81	0
Mont:	Helena	19	5	3.12	.32	1.20	Apr 68	(*)	5	34	64
Nebr:	Lincoln	20	5	4.73	.73	1.98	Aug 68	(*)	5	37	0
Nebraska:	Las Vegas	5		2.71	.17	1.31	Jan 68	(*)			
N. H:	Concord	21	5	1.57	.38	.98	June 68	(*)			
N. J:	Trenton	19	2	1.24	.04	.61	July 68	(*)	2	19	0
N. Mex:	Santa Fe	22	4	1.39	.20	.62	Apr 68	(*)	4	14	5
N. Y:	Albany	22	3	2.13	.19	.80	Aug 68	(*)	3	31	28
	Buffalo	20		4.98	.31	.89	Mar 68	(*)			
	New York City	21	7	.93	.19	.39	Apr 68	(*)			
N. C:	Gastonia	16	7	12.24	1.08	4.68	Mar 68	(*)	(*)	(*)	(*)
N. Dak:	Bismarck	19	1	4.87	.44	1.47	June 68	(*)	0	0	(*)
Ohio:	Cincinnati	21		2.75	.35	1.34	Nov 67	(*)			
	Columbus	20	7	2.92	.41	1.12	July 68	(*)	3	26	0
	Fainesville	15	8	2.45	.38	.98	Jan 68	(*)	8	79	51
Okla:	Oklahoma City	17	2	4.09	.31	.95	May 68	(*)	2	35	19
Okla:	Ponca City	21	7	2.40	.00	.96	Jan 68	(*)	7	93	0
Ore:	Portland	22	12	.91	.00	.34	Aug 68	(*)	12	56	0
Pa:	Harrisburg	15		2.84	.60	1.28	Aug 68	(*)			
P. R:	San Juan	(*)					July 68	(*)			
P. R. I:	Providence	20	1	.23	.28	.30	May 68	(*)	0	0	(*)
S. C:	Columbia	19	6	1.61	.06	.64	Apr 68	(*)	0	0	(*)
S. Dak:	Pierre	10		4.91	.26	1.46	Feb 68	(*)			
Tenn:	Nashville	18	7	1.95	.34	.84	May 68	(*)	7	92	0
Tex:	Austin	18	6	6.35	1.22	2.74	Nov 67	(*)	(*)	(*)	(*)
	El Paso	21	2	4.70	1.57	2.57	June 68	(*)	2	2	0
Utah:	Salt Lake City	28	10	2.28	.57	1.12	July 68	(*)	0	0	(*)
Vt:	Barre	21	7	2.85	.34	.96	Dec 67	(*)	7	63	1
Va:	Richmond	16	8	.84	.35	.63	Dec 67	(*)	2	25	0
Wash:	Seattle	24	8	.73	.00	.03	Dec 67	(*)	(*)	(*)	(*)
	Spokane	22		3.15	.75	1.58	Nov 67	(*)	11	81	73
W. Va:	Charleston	8	11	2.01	.26	.75	Apr 68	(*)	9	113	142
Wis:	Madison	21	9	1.98	.19	.55	Dec 67	(*)	3	53	24
Wyo:	Cheyenne	20	4	4.84	.69	1.69	Jan 68	(*)			
Network summary		1,310	274	13.24	0.00	1.12		55	5	50	23

- * The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
^b No report received. (Air samples received without field estimate data are not considered by the data program).
 * No precipitation samples collected.
 * This station is part of the plutonium in precipitation network. No gross beta measurements are performed on the sample.
 * Samples were collected but no field estimates were reported.

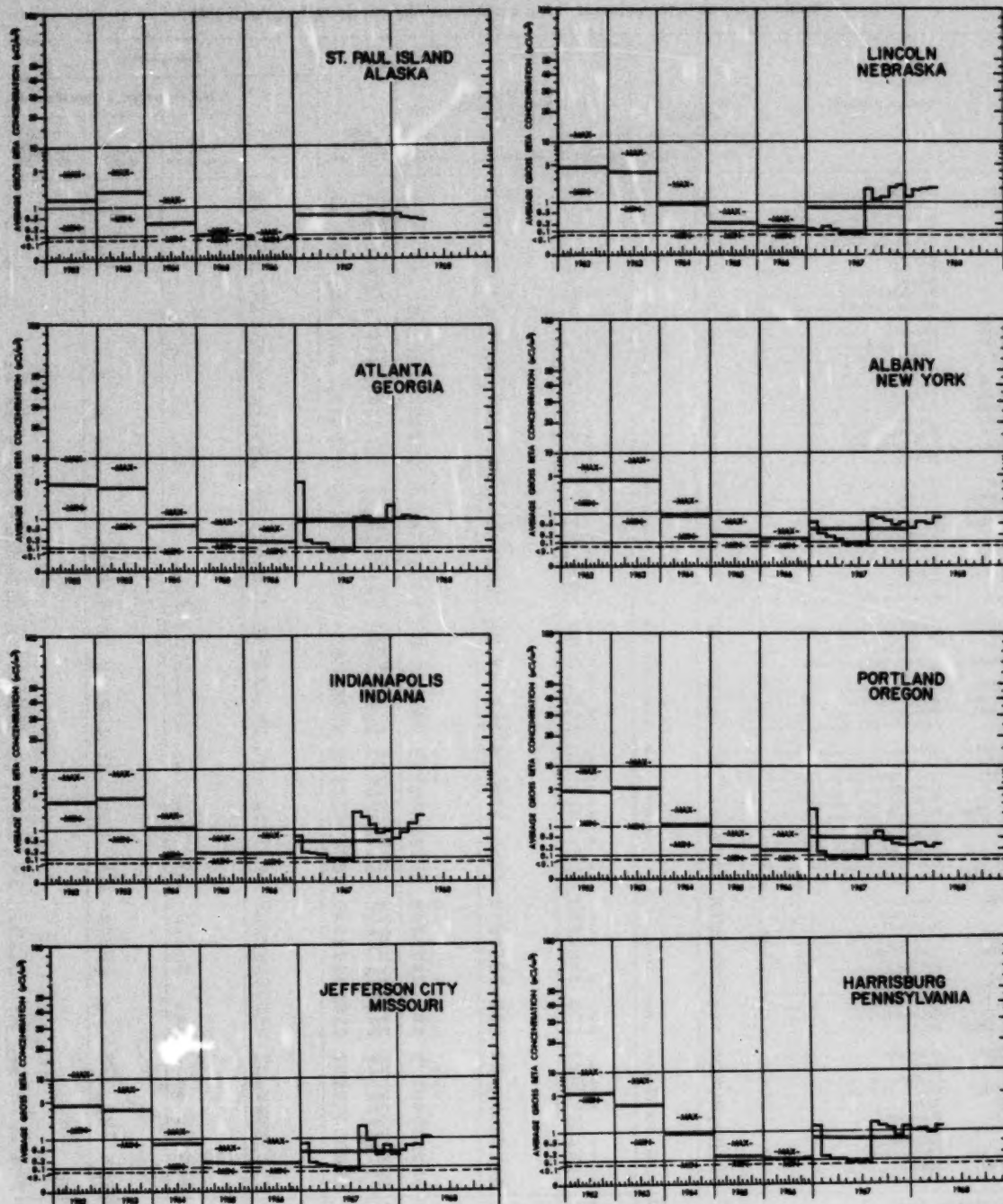


Figure 2. Monthly and yearly profiles of beta radioactivity in Air-Radiation Alert Network, 1962-April 1968

2. Canadian Air and Precipitation Monitoring Program, April 1968¹

*Radiation Protection Division
Department of National Health and Welfare*

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (2-6).

A summary of the sampling procedures and methods of analysis was presented in the July 1968 issue of *Radiological Health Data and Reports*.

¹ Prepared from information and data in the May 1968 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for April 1968 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, April 1968

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m ³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (mCi/m ²)
Calgary	30	0.4	0.0	0.2	NB	NB
Coral Harbour	30	.2	.1	.1	25	1.3
Edmonton	30	.6	.1	.3	44	1.0
Ft. Churchill	30	.4	.1	.3	80	0.9
Ft. William	29	.3	.1	.2	130	9.8
Fredericton	30	.2	.0	.2	28	4.5
Goose Bay	30	.3	.1	.1	65	3.1
Halifax	30	.4	.0	.3	140	9.8
Inuvik	30	.2	.0	.1	77	1.3
Montreal	29	.5	.0	.3	78	4.7
Moosemen	30	.5	.0	.3	25	3.2
Ottawa	34	.4	.0	.3	135	5.0
Quebec	30	.3	.1	.2	81	5.2
Regina	30	.5	.1	.3	239	0.7
Resolute	28	.3	.1	.1	17	.1
St. John's, Nfld.	30	.3	.0	.1	94	5.9
Saskatoon	30	.5	.0	.3	19	0.5
Sault Ste. Marie	29	.5	.0	.3	64	3.1
Toronto	30	.4	.0	.3	55	1.3
Vancouver	30	.5	.0	.1	131	4.3
Whitehorse	5	.2	.0	.1	84	0.3
Windsor	30	.4	.1	.2	157	7.2
Winnipeg	29	.4	.1	.2	89	2.9
Yellowknife	30	.3	.1	.2	15	0.3
Network summary		0.6	0.0	0.2	82	3.4

NB, no sample.



Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program April 1968

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the

Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6 by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20 hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental,

Table 4. Mexican gross beta radioactivity in airborne particulates, April 1968

Station	Number of samples	Gross beta radioactivity (pCi/m ³)		
		Maximum	Minimum	Average
Acapulco	13	1.1	0.1	0.4
Chihuahua	14	1.3	.3	.6
Ciudad Juárez	2	0.8	.1	—
Ensenada	NS	NS	NS	NS
Guadalajara	NS	NS	NS	NS
Guaymas	NS	NS	NS	NS
La Paz	9	1.1	.1	.9
Matamoros	NS	NS	NS	NS
Monterrey	NS	NS	NS	NS
Mérida	4	1.0	.2	.6
México, D. F.	9	2.1	.1	.5
Nuevo Laredo	NS	NS	NS	NS
San Luis Potosí	NS	NS	NS	NS
Tampico	18	.7	.1	.3
Torreón	17	.5	.1	.3
Veracruz	3	.3	.1	—

NS, no sample, temporarily shut down.

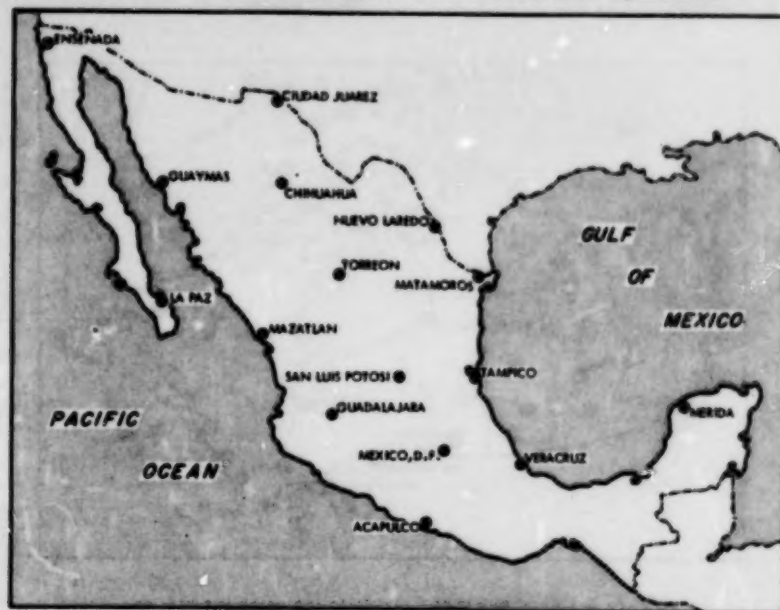


Figure 4. Fallout network sampling stations in Mexico

CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of

five samples per month were needed to get a reliable average radioactivity at each station (7).

The maximum, minimum, and average beta radioactivity in surface air during April 1968 are presented in table 4.

4. Pan American Air Sampling Program April 1968

Pan American Health Organization and U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling locations are shown in figure 5. Analytical techniques were described in the January 1968 *Radiological Health Data and Reports*. The April 1968 air monitoring

results from the participating countries are given in table 5.

Table 5. Gross beta radioactivity in Pan American surface air, April 1968

Station location	Number of samples	Gross beta radioactivity ($\mu\text{Ci}/\text{m}^3$)		
		Maximum	Minimum	Average *
Argentina: Buenos Aires.....	17	0.03	0.01	0.02
Bolivia: La Paz.....	19	.05	.01	.02
Chile: Santiago.....	28	.03	.01	.02
Colombia: Bogotá.....	20	.04	.00	.02
Ecuador: Guayaquil.....	17	.06	.02	.04
Jamaica: Kingston.....	17	.48	.21	.30
Peru: Lima.....	13	.05	.01	.02
Venezuela: Caracas.....	8	.43	.01	.13
West Indies: Trinidad.....	18	.25	.06	.13
Summary.....	158	0.48	0.00	0.07

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of less than 0.005 $\mu\text{Ci}/\text{m}^3$ are reported and used in averaging as 0.00 $\mu\text{Ci}/\text{m}^3$.



Figure 5. Pan American Air Sampling Program stations
August 1968

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- (2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual Report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).
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- (7) VASQUEZ, M., and R. M. De NULMAN. Estudios sobre la radioactividad ambiental en la República Mexicana, 1963-1966. Comisión Nacional de Energía Nuclear, Dirección General de Seguridad Radiológica (1968).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained

from human bone sampling, bovine thyroid sampling. Alaskan surveillance and environmental monitoring around nuclear facilities.

Iodine-131 in Bovine Thyroids, January-March 1968

National Center for Radiological Health Public Health Service

The National Center for Radiological Health established a bovine thyroid network in October 1964 (1). Specimens are collected by the Livestock Slaughter Inspection Division, U.S. Department of Agriculture, and are analyzed by gamma-ray spectroscopy for iodine-131 content at the Northeastern Radiological Health Laboratory, Winchester, Mass.

The network consists of collection areas (counties shaded in figure 1) located so as to cover, as nearly as possible, areas near major nuclear test sites. Details of sampling and analyses have been published earlier (1).

The results for January through March 1968 appear in table 1 and are listed chronologically within each State. Moderate elevations in radioactivity were found in 8 States during parts of January and February. The most active sample analyzed was collected in Brule County, South Dakota on January 24th and contained 83 pCi iodine-131/g thyroid.

REFERENCE

- (1) BARATTA, E. J., E. R. WILLIAMS, and G. MURRAY. Iodine-131 in bovine thyroids, October-December 1964. *Radiol Health Data* 6:569-571 (October 1965).



Figure 1. Counties sampled in bovine thyroid network, January-March 1968

Table 1. Iodine-131 in bovine thyroids, January-March 1968

State	Date(s) of slaughter	County	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
Arizona	1/8	Maricopa	3	ND	ND	11
	1/10	Maricopa	2	6		
	1/10-3/28	Maricopa (18) Santa Cruz (2)	20	ND		
California	1/4-3/29	Fresno (1) Kings (1) San Joaquin (1) San L. Obispo (1) Santa Barbara (1) Los Angeles (2)	7	ND		
Georgia	1/2	Cherokee	2	1	ND	3
		Gilmer	1	ND		
		Lumpkin	2	5		
	1/15	Union	2	1	ND	3
		White	2	3		
		Washington	10	10		
	1/28	Bibb	3	2	ND	5
		Columbia	4	4		
		DeKalb	3	26		
	1/29	Screven	4	8	ND	22
		Washington	6	2		
		Waynes	2	27		
	2/6	Walton	3	15	ND	39
		Waynes	2	5		
		Laurens	3	10		
	2/20	Barrow	2	9	ND	11
		Waynes	3	9		
		Laurens	3	2		
	2/28	Bibb	3	1	ND	3
		Butts	2	ND		
		Screven	2	ND		
	3/7-3/27	Wilkes	2	5	3	8
		Barrow (5)	5	ND		
		Bibb (3)	3	ND		
		Butts (3)	3	ND		
		Candler (3)	3	ND		
		Clarke (4)	4	ND		
		DeKalb (2)	2	ND		
		Waynes (2)	2	ND		
		Glenn (2)	2	ND		
		McDuffie (3)	3	ND		
		Screven (6)	6	ND		
Idaho	1/19-3/22	Ada (2)	2	ND		
		Canyon (4)	4	ND		
		Gem (2)	2	ND		
		Owyhee (5)	5	ND		
		Shoshone (4)	4	ND		
Iowa	2/27	Lyon	6	ND	ND	3
	3/27	Lyon	3	2		
Kansas	1/10	Douglas	1	ND		
	1/24	Johnson	1	10		
Louisiana	1/8	Bossier	1	10		
	1/13	Dubuque	1	7		
	1/24	Bossier	1	10		
	3/6	Chalmer	1	ND		
	3/13	Chalmer	1	ND		
Minnesota	2/20	Rock	4	ND		
New York	1/11-2/21	Chautauque	30	ND		
North Carolina	1/10	Cleveland	2	20	22	55
	2/20	Cleveland	2	12		
Oklahoma	1/3	Carter	1	ND		
	1/15	Choctaw	1	68		
	1/17	Jefferson	1	ND		
	1/19	McCurtain	1	42		
	2/2	Carter	1	30		
	2/6	Carter	1	88		
	3/15	Bryan	1	ND		
Oregon	1/19	Malheur	1	ND		
South Carolina	1/10	Alcon	1	ND	ND	16
		Barrow	1	10		
		Orangeburg	4	8		
	2/7	Orangeburg	1	43	ND	9
		Orangeburg	3	7		
		Orangeburg	3	3		
	2/13	Colleton	2	ND	ND	3
		Richland	2	2		
	3/27	Richland	2	2	3	3

See footnotes at end of table.

State	Date(s) of slaughter	County	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
South Dakota	1/3	Aurora	5	1	ND	4
		James	2	3	ND	8
	1/3	Aurora	2	ND		
	1/23	Tripp	1	ND		
	1/24	Brule	9	41	5	88
	1/29	Tripp	9	14	3	54
	1/30	Minnehaha	1	ND		
	2/7	Aurora	1	21		
		Brookings	1	4		
		Brule	1	ND		
	2/8	Charles Mix	5	9	ND	14
	2/12	Tripp	3	2	ND	5
	2/14	Brule	7	3	ND	18
	2/20	Brule	1	15		
		Devon	2	8	3	4
	2/22	Brule	1	9	ND	16
		Charles Mix	1			
	2/27	Minnehaha	3	ND		
	3/4	Corson	2	ND		
	3/4	Tripp	5	2	ND	7
	3/5	Lincoln	1	9		
	3/5	Minnehaha	1	4		
	3/12	Charles Mix	10	ND		
	3/19	Brookings	10	ND		
	3/26	Devon	3	2	ND	3
	3/27	Lincoln	2	1	ND	2
Tennessee	1/4	Blount	4	3	ND	13
		Monroe	1	ND		
		Sevier	1	ND		
	1/11	Blount	2	29	22	36
		Knox	1	ND		
		Monroe	1	5		
		Sevier	1	4		
	1/18	Blount	2	9	5	13
		Knox	1	ND		
	1/25	McMinn	1	40		
		Blount	1	ND		
		Fentress	1	7		
		Knox	1	8		
	2/2	Blount	1	5		
		Knox	3	12	4	18
	2/8	Blount	2	7	5	8
		Loudon	1	8		
		Sevier	1	3		
	2/30	Blount	3	11	ND	34
	2/21-	Anderson (1) ^a	23	^b ND		
	3/27	Blount (5)				
		Cumberland (2)				
		Grainger (1)				
		Jefferson (1)				
		Knox (9)				
		Roane (3)				
		Sevier (1)				
Texas	1/3	Denton	1	ND		
	1/30	Denton	1	39		
	2/6	Hopkins	1	10		
	2/12	Denton	1	49		
	2/13	Denton	1	35		
	2/14	Cooke	1	41		
	2/23	Hopkins	1	ND		
	2/28	Hopkins	1	ND		
	2/29	Titus	1	ND		
	3/6	Denton	1	10		
	3/12	Denton	1	8		
	3/18	Hopkins	1	9		
	3/27	Hopkins	1	ND		
Vermont	1/9-	Franklin ^a	60	^b ND		
	3/30					
Washington	1/5	Walla Walla	1	ND		
Wisconsin	1/11-	Dane (14) ^a	45	^b ND		
	3/13	Green (2)				
		Rock (24)				
		Sauk (3)				

^a Samples were not collected on all dates during this period, but the interval includes several sampling dates.

^b The results for this period were for the most part not detectable. Some randomly scattered positive results were obtained; but these represented barely detectable amounts of iodine-131 in the bovine thyroid (2 to 5 pCi/g).

^c Numbers in parentheses represent the number of samples collected from that county during the interval indicated. These may have been collected over several dates or on only one date.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational

Safety in directives published in the AEC Manual.¹

Summaries of data from the environmental radioactivity monitoring reports follow for the Argonne National Laboratory and Feed Materials Production Facility.

¹Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Argonne National Laboratory July-December 1967^{*}

*University of Chicago
Lemont, Illinois*

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally-occurring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually spread by air and water, the environmental monitoring program at Argonne has concentrated on these materials. The sampling locations discussed in this report are shown in figures 1 and 2.

Air monitoring

Air-filter samples were collected continuously at seven locations on the Argonne site and at five locations off the site. The alpha and beta radioactivity in air-filter samples are summarized in table 1. The alpha radioactivity concentrations were normal both on and off the site and in the range found in previous years. The beta radioactivity was presumed to result from fission and neutron-activation products

from nuclear detonations. The decrease in beta radioactivity during the year was due to the disappearance from the atmosphere of the shorter-lived fission products, such as barium-lanthanum-140, cerium-141, iodine-131, and zirconium-niobium-95. The latter pair of radio-nuclides reappeared during the last 4 months of the year, concentrated in a few discrete particles on each filter paper sample in which it was present in above normal amounts. This behavior is attributed to insoluble particulate fallout from the stratosphere. The average beta radioactivity for the year, 0.11 pCi/m³, was 0.04 pCi/m³ less than during 1966. The similarity between alpha, beta, and fission product activities on and off the site indicates that Argonne did not add significantly to the particulate airborne activity of the environment. Significant releases by Argonne would have been detected in the form of an increase in the onsite activity over the offsite activity.

Sampling on charcoal, specifically for gaseous radioiodine was conducted continuously on the site. Iodine-131, released from building 330, was detected beginning September 20 at a maximum concentration of 0.3 pCi/m³, or 0.3 percent of the AEC standards. This activity diminished to 0.1 pCi/m³ one week later, and remained at that level for several weeks. Detectable surface deposition of radioiodine from this release was confined to 100 yards of the building. None was detected off the site.

^{*} Summarized from "Environmental Radioactivity at Argonne National Laboratory, July-December and Annual Summary 1967," University of Chicago, Lemont, Ill.

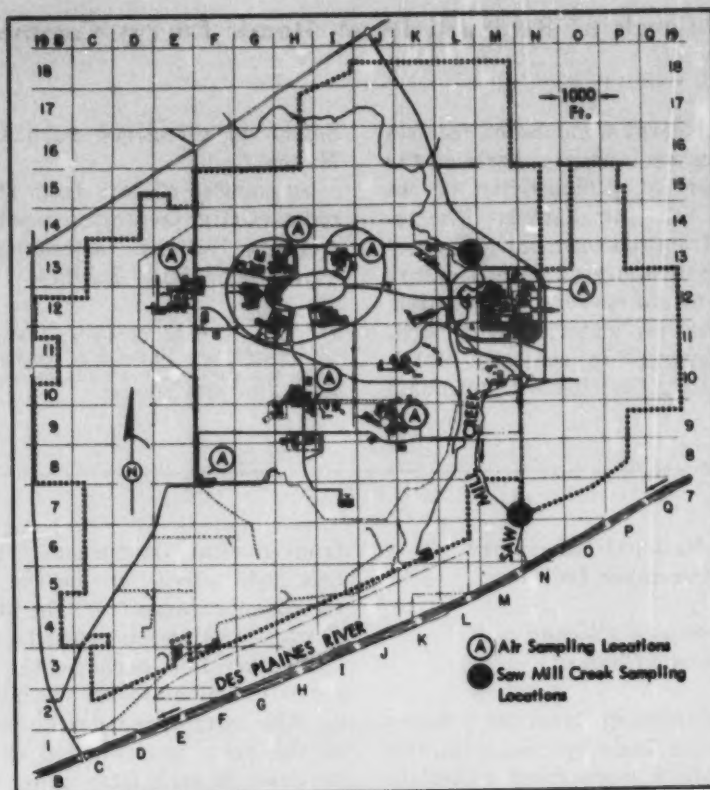


Figure 1. Sampling locations on the site of Argonne National Laboratory

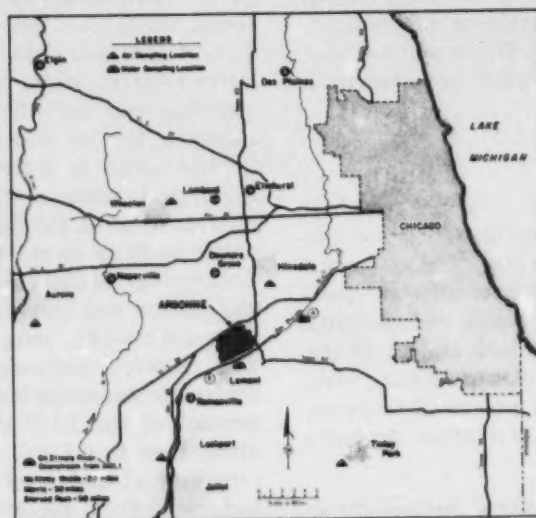


Figure 2. Site location of Argonne National Laboratory (including some offsite sampling stations)

Table 1. Alpha and beta radioactivity in air-filter samples, Argonne National Laboratory,^a July-December and annual summary 1967

Period (1967)	Location	Number of samples	Alpha radioactivity (pCi/m ³) multiply by 10 ⁻⁴			Beta radioactivity (pCi/m ³)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July.....	onsite.....	27	0.50	0.23	1.16	0.04	0.02	0.06
	offsite.....	17	.48	.17	.61	.05	.02	.09
August.....	onsite.....	27	.48	.21	1.14	.04	.03	.08
	offsite.....	22	.53	.27	.96	.04	.03	.08
September.....	onsite.....	24	.56	.31	1.31	.04	.02	.06
	offsite.....	22	.67	.31	1.57	.04	.02	.07
October.....	onsite.....	20	.40	.19	.80	.05	.02	.12
	offsite.....	22	.38	.17	.81	.04	.02	.08
November.....	onsite.....	19	.34	.16	.56	.04	.02	.10
	offsite.....	21	.41	.19	1.00	.05	.02	.12
December.....	onsite.....	20	.35	.20	.55	.06	.02	.11
	offsite.....	23	.35	.16	.70	.05	.02	.20
July-December.....	onsite.....	137	0.44	0.18	1.21	0.04	0.02	0.52
	offsite.....	126	0.47	0.18	1.57	0.04	0.02	0.20
Annual summary.....	onsite.....	288	0.43	0.16	1.21	0.11	0.02	1.14
	offsite.....	256	0.46	0.16	1.57	0.12	0.02	1.45

^a These results were obtained by measuring the samples 4 days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products.

Water monitoring

Argonne wastewater is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the wastewater discharge. Sawmill Creek was sampled above and below the discharge to evaluate the effect of the wastewater on the radioactivity in the creek. The sampling locations are shown in figure 2.

Below the wastewater outfall the creek was usually sampled three times weekly. Since it was impractical to analyze all the samples for all the nuclides and elements desired, equal portions of the three samples collected each week were combined and analyzed. The results obtained in this way represent the average

concentrations in the weekly samples. Above the site, samples were collected at weekly intervals, and at least one sample each month was analyzed for each radioactive nuclide of interest. The total alpha and beta radioactivities found in Sawmill Creek during the second half of 1967 are given in table 2.

The alpha-particle emitters most likely to be present in Argonne wastewater are isotopes of uranium, plutonium, and thorium. The alpha radioactivity in the creek water due to these elements are summarized in table 3. The average uranium concentrations below the outfall was about 20 percent higher than during 1966 while the plutonium and thorium concentrations this year averaged less than the minimum detectable amount.

Table 2. Non-volatile alpha and beta radioactivity in Sawmill Creek water, Argonne National Laboratory, July-December and annual summary 1967

Month (1967)	Location ^a	Number of samples	Alpha radioactivity (pCi/liter)			Beta radioactivity (pCi/liter)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July.....	Upstream.....	2	0.7	0.6	0.9	7.4	6.5	8.4
	Downstream.....	12	1.3	.8	2.0	28	15	44
August.....	Upstream.....	2	1.4	.8	2.1	17	13	21
	Downstream.....	12	4.6	2.7	9.3	19	14	29
September.....	Upstream.....	2	5.0	4.0	6.0	30	22	38
	Downstream.....	15	2.3	1.0	6.5	21	16	31
October.....	Upstream.....	2	2.5	1.7	3.2	15	12	17
	Downstream.....	12	2.2	1.0	2.8	15	12	20
November.....	Upstream.....	2	2.3	2.3	2.3	9	7.7	11
	Downstream.....	12	2.6	2.1	3.8	13	9.2	18
December.....	Upstream.....	2	3.5	3.0	4.0	7.7	6.9	8.6
	Downstream.....	15	2.5	2.2	4.1	13	10	15
Annual summary.....	Upstream.....	23	2.4	0.6	6.0	13	3.0	38
	Downstream.....	156	2.4	0.3	9.3	21	8.7	86

^a Relative sampling location with respect to Argonne wastewater outfall (figure 1).

**Table 3. Alpha-emitting elements in Sawmill Creek water
Argonne National Laboratory, July-December 1967**

Element	Location ^a	Number of samples	Concentration (pCi/liter)			Average as a percent of AEC standard
			Average	Minimum	Maximum	
Uranium	Upstream	13	1.9	0.7	2.7	0.005
	Downstream	75	1.6	.6	6.0	.004
Plutonium	Upstream	6	—	—	<.05	—
	Downstream	36	.05	<.05	.16	.001
Thorium	Upstream	6	—	—	.05	—
	Downstream	36	<.05	<.05	.06	<.003

^a Relative sampling location with respect to Argonne wastewater outfall (figure 1).

Table 4. Average radioactivity in Des Plaines and Illinois River water, Argonne National Laboratory, July-December 1967

Location	Concentration (pCi/liter)	
	Non-volatile alpha radioactivity	Non-volatile beta radioactivity
Des Plaines River ^a (above Sawmill Creek)...	4.4	14
Des Plaines River ^b (below Sawmill Creek)...	3.2	13
Illinois River ^c	3.2	8

^a Sampled near Route 45, upstream from the mouth of Sawmill Creek.
^b Sampled near Lemont, downstream from the mouth of Sawmill Creek.
^c Sampled at McKinley Woods State Park, Starved Rock State Park, and Morris, on October 18, 1967.

In addition to the natural beta radioactivity in the creek, beta radioactivity from fallout was detected at both sampling locations and beta radioactivity from Argonne wastewater was found in some samples below the outfall. The natural beta radioactivity is approximately 5 pCi/liter above the site and 3 pCi/liter below the site. The Argonne contribution to the total beta radioactivity below the outfall during the second half of 1967 is estimated to be approximately 10 pCi/liter, about one-fourth of the 1966 value.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in the latter two streams is important in assessing the contribution of Argonne wastewater to the environmental radioactivity. The Des Plaines River was sampled monthly above, and weekly below, the mouth of Sawmill Creek to determine if the radioactivity in the creek had any effect on the radioactivity in the river. The total radioactivity is summarized in table 4. The average concentrations were very similar at both locations, indicating that Sawmill Creek water had

no significant effect on the radioactivity in the river. The alpha and beta radioactivities were not significantly different from the 1966 averages. The natural beta radioactivity in the river is 5 to 10 pCi/liter, and the additional radioactivity, about 7 pCi/liter on the average was due to fallout.

The Illinois River was sampled at McKinley Woods, Morris and Starved Rock State Park on October 18. The total radioactivity in these samples were similar to those found in other bodies of water in the area and to the radioactivity found previously at these same locations. No radioactivity originating at Argonne was detected in the Des Plaines or Illinois Rivers.

Radioactivity in milk

Raw milk was collected monthly from a local dairy farm and analyzed for several fission products. Barium-140, strontium-89, and iodine-131 were not present in concentrations greater than the minimum detectable amounts of 20 pCi/liter for iodine-131 and 3 pCi/liter for the other two nuclides. The cesium-137 and strontium-90 concentrations are given in table 5. These two nuclides are long-lived fission products from past nuclear tests and their presence in milk is not related to Argonne operations. The strontium-90 concentrations averaged approximately 1.5 pCi/liter less than during 1966, while the cesium-137 content was about 40 pCi/liter higher than the 1966 average.

**Table 5. Fission product concentrations in milk
July-December 1967**

Collection date 1967	Concentrations (pCi/liter)	
	Cesium-137	Strontium-90
July 5.....	125	7.6
August 3.....	148	5.4
September 6.....	88	7.0
October 5.....	103	4.8
November 2.....	80	6.0
December 6.....	90	10.3
Average.....	100	6.8

Recent coverage in Radiological Health Data and Reports:

Period	Issue
July-December and annual summary	September 1967
January-June 1967	March 1968

2. Feed Materials Production Center July-December 1967^{*}

*National Lead Company
Fernald, Ohio*

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 3. Cincinnati and Hamilton, the larger nearby communities, are situated 20 and 10 miles from the center, respectively. Operations at this project deal with the processing of high-grade uranium ores and ore concentrates to produce metallic uranium and with fabricating the metal into fuel elements.

During the many involved reactions and processes that lead to the production of reactor fuels, various liquid and airborne wastes are generated. These wastes contain varying quantities of uranium. Various in-plant methods are used to curtail their release into the environment surrounding the plant. Almost complete removal of the materials is accomplished by using dust collectors and waste treatment processes. In order to determine what concentrations reach the area surrounding the project an environmental survey program has been established which consists of wastewater, soil, and air sampling of the environs and performing those analyses on the samples that are indicative of material released from the plants.

Onsite air samples are obtained from four permanent perimeter air sampling stations, located at the four corners of the production area as shown in figure 4. Samples from these perimeter stations are collected once each week and analyzed for uranium and total radioactivity. Offsite samples are collected by a mobile air sampling unit. The location at which samples are collected is determined by local meteorological conditions on the day of sampling. Approximately 20 percent of all samples are taken upwind of the FMPC plant. Replicate samples are taken at each sampling point and

^{*}Summarized from "Feed Materials Production Center Environmental Monitoring Semiannual Report for the Second Half of 1967, Summary Report for 1967," (NLCO-1013).

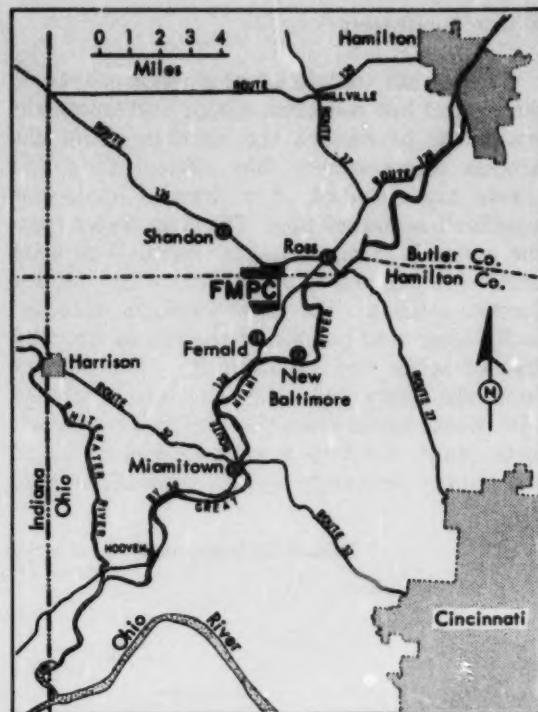


Figure 3. Area map of Feed Materials Production Center averaged to obtain a representative concentration for that location. Concentrations of uranium and total radioactivity of airborne particulates sampled at onsite and offsite locations are given in table 6.

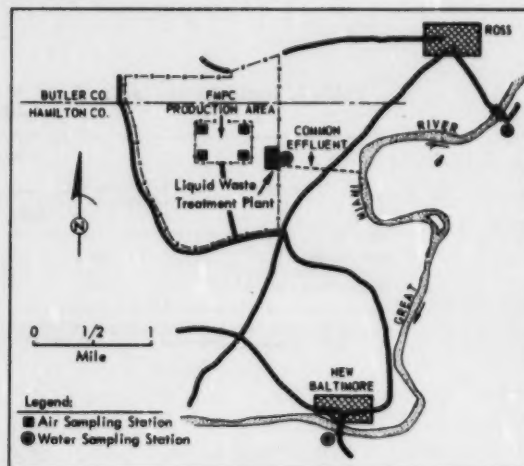


Figure 4. Air and water sampling stations, FMPC

Water monitoring

Each of the individual production plants on the project has collection sumps and treatment equipment to remove the uranium from the process waste water. The effluent from the plants are collected at a general sump for equalization and settling. The clear water from the sump is pumped to the river. The solid portion is pumped to a chemical waste pit for further settling. The flow, which is decanted to the clear well portion of the pit, is virtually free of solids and radioactivity. The effluent from the sump and clear well are combined with waste water from the FMPC water treatment plant, sanitary sewage treatment plant, and storm sewerage system and discharged

via a common effluent outfall into the Great Miami River. A weir-type water sampler collects samples of the combined effluent stream, which are removed and analyzed daily. These results are utilized with measurements of river flow in calculating the radioactive contaminant concentrations added to the river. Weekly spot samples are also obtained upstream and downstream from the common FMPC effluent at locations shown in figure 4. The results of the FMPC water monitoring program for July-December 1967 are summarized in table 7.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July-December 1966	August 1967
January-June 1967	March 1968

Table 6. Radioactivity levels of airborne particulates, Feed Materials Production Center, July-December 1967

Location	Number of samples	Uranium concentration ^a (pCi/m ³)			Total radioactivity ^b (pCi/m ³)		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Onsite:							
Southwest.....	25	0.7	<0.1	0.1	1.8	<0.1	0.3
Northwest.....	25	.4	<.1	<.1	0.8	<.1	.1
Northwest.....	25	.4	<.1	.1	1.0	<.1	.2
Southwest.....	25	.5	<.1	.1	.8	<.1	.2
All onsite samples.....	100	.7	<.1	.1	1.8	<.1	.2
Offsite:							
0-2 miles from FMPC.....	55	1.1	<.1	.1	3.5	<.1	.4
2-4 miles from FMPC.....	25	1.1	<.1	.2	2.1	<.1	.5
4-8 miles from FMPC.....	24	.3	<.1	<.1	.4	<.1	<.1
8-12 miles from FMPC.....	12	<.1	<.1	<.1	<.1	<.1	<.1
All offsite samples.....	116	1.1	<.1	.1	3.5	<.1	.3

^a AEC radiation protection standard-2 pCi/m³.

^b AEC radiation protection standard-100 pCi/m³.

Table 7. Radioactivity in the Great Miami River, Feed Materials Production Center July-December 1967

Location	Number of samples	Uranium concentration ^a (pCi/liter)			Total radioactivity ^b (pCi/liter)		
		High	Low	Average	High	Low	Average
Sewer outfall.....	184	<10	<10	<10	170	<10	160
Upstream from outfall.....	25	<10	<10	7	210	<10	30
Downstream from outfall.....	29	60	<10	10	90	<10	40

^a AEC radiation protection standard-20,000 pCi/liter.

^b AEC radiation protection standard-3,000 pCi/liter.

Reported Nuclear Detonations, July 1968

The U.S. Atomic Energy Commission announced that the United States recorded seismic signals originating north of the Caspian Sea on July 1, 1968. The signals were equivalent to those of a nuclear test in the low-intermediate range (20-200 kilotons TNT equivalent).

Announcement was also made by the U.S. Atomic Energy Commission that a nuclear test of low-intermediate yield (20 to 200 kilotons TNT equivalent) was conducted underground at its Nevada Test Site on July 30, 1968.

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SYNOPSIS

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

LEVELS OF IRON-55 IN HUMANS, ANIMALS, AND FOOD, 1964-1967. H. E. Palmer, J. C. Leonard, T. M. Beasley, C. E. Jenkins, and J. M. Aase. *Radiological Health Data and Reports*, Vol. 9, August 1968, pp. 387-390.

Iron-55 levels in the foods of humans have been decreasing since 1964 with the exception of caribou obtained from Arctic areas, which showed peak levels in 1965. The levels of iron-55 in humans at Richland, Wash., increased until about January 1967, and then began to decrease. This peak level in humans occurred about 4 years after the 1962 nuclear test series. This lag time of 4 years is much longer than that for cesium-137 in humans where peak levels occurred 1½ years after the nuclear tests stopped.

KEYWORDS: Body burdens, fallout, fish, foods, humans, human food chain, iron-55, nuclear tests.

CESIUM-137 LEVELS IN FLORIDA BEEF — VARIATIONS WITH FEEDING PROGRAM. C. E. Roessler, B. G. Dunavant, H. A. BEVIS, and G. S. Roessler. *Radiological Health Data and Reports*, Vol. 9, August 1968, pp. 391-396.

Levels of cesium-137 in low quality lean beef samples, collected in the vicinity of Gainesville, Fla., in the spring of 1967, averaged 4,000 pCi/kg and ranged from 290 to 12,500 pCi/kg. The average and maximum levels in these samples from eight grass-fed animals were considerably higher than those in samples from 26 grain-fed animals from five peninsular Florida feed lots. The levels in the grass-fed animals suggest very high levels of cesium-137 intake by the animals, an extremely high feed-to-meat transfer, or both. For persons whose meat consumption is represented by the grass-fed animals examined in this study, it can be expected that meat exceeds all other commodities as the source of cesium-137 intake.

KEYWORDS: Beef, cesium-137, feeding program, Florida, grain-fed, grass-fed.

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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 9, Number 9, September 1968

In August 1956, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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RADIOLOGICAL HEALTH DATA AND REPORTS

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Dr. Raymond T. Moore, Deputy Director
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Detection of Elevated Fallout Levels in California, January 1967

Amasa C. Cornish and George Uyesugi¹

California received a heavy fallout of radioactive debris beginning 4.5 days after a foreign nuclear device was detonated in the atmosphere on December 27, 1966. Highest air particulate levels occurred in Berkeley and Sacramento. Values obtained after allowing 3 days decay were 98 pCi/m³ of air for both. Other air sampling stations had lesser amounts of fallout and Fresno received essentially no fallout. All milk-sheds in California were contaminated to some extent with radioactive iodine. Del Norte and Humboldt milk with 397 and 280 pCi/liter, respectively, contained the highest concentrations of iodine-131. These values were estimated to result in thyroid doses to children of 33 and 23 mrad, respectively. The apparent half-life for iodine-131 in the environment was calculated to be 3.2 days.

Atmospheric testing of nuclear weapons by foreign nations has prompted the State of California Department of Public Health to be alert for possible environmental contamination resulting from these tests. One such test was conducted on December 27, 1966. The energy yield was reported as the equivalent of a few hundred kilotons of TNT (1). The location of the detonation was approximately 90 degrees east longitude and 40 degrees north latitude. The fortieth degree north latitude crosses northern California, 180 miles north of San Francisco, some 8,000 miles east of the explosion site.

Tropospheric fallout occurs in the same general latitude as the test site (2). California lies directly in the path of any tropospheric cloud generated west of the State on the fortieth parallel north.

Air network

The California air network, depicted in figure 1, consists of 14 stations distributed

¹ Mr. Cornish is senior health physicist and Mr. Uyesugi, radiochemist, both with California State Department of Public Health, 2151 Berkeley Way, Berkeley, Calif. 94704.



Figure 1. California air network

throughout the State. Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter-diameter membrane filter of 0.8 micron pore size, using a Gast air pump of about 80-cubic meters per day capacity. Filters at 4 stations are replaced every 24 hours at 0800 during the workweek, weekends, and holidays. The remaining 10 stations are staffed only during the workweek. Of these, samples for weekends and holidays are continuous samples of 48 hours for a 1-day holiday, 72 hours for a normal weekend, and 96 hours for the 1967 New Year's 3-day holiday weekend. Fresh fission debris from the December 27, 1966, foreign test arrived in California during the 3-day New Year's holiday.

Unfortunately, the exact arrival time cannot be determined from our air data, as only 4 stations replaced filters each day over the long weekend. Of these, only the Berkeley station showed increased fallout levels on the filter samples which were removed at 0800, Sunday, January 1. The levels of gross beta radioactivity in pCi/m³ as measured on Berkeley air samples beginning with the 24-hour sample removed December 30, 1966, are given in table 1.

As noted in table 1, radioactive debris was measured in the surface air at Berkeley sometime between midnight and 0800, January 1, 1967, approximately 4.5 days after detonation. Since the detonation site is about 8,000 miles

from Berkeley, along the fortieth parallel, the radioactive debris must have traveled a minimum of 75 miles per hour to reach Berkeley in 4.5 days. The other three stations from which daily measurements were made during this time did not show arrival of the debris until January 2.

The meteorological conditions about the time of January 1, 1967, are not presented in this article. However, it is not unusual for a weather front to strike Berkeley before Santa Rosa, nor is it unusual to have different fallout patterns in Los Angeles, San Bernardino, El Centro, Barstow, and San Diego. Absence of fallout at Fresno cannot be explained except by assuming that the debris did not pass over Fresno or was not deposited because of meteorological conditions.

Reasons for placing more emphasis on the Berkeley air sample are as follows:

1. this sample is located at the Berkeley radiological laboratory;
2. the sample can be counted when removed and as often as deemed necessary;
3. samples from other stations are sent to the laboratory by mail for counting and therefore arrive 2 or 3 days after removal;
4. in determining the age of the fallout, it was convenient to use the Berkeley sample because of the early count (first and second day). Also, a decision was made to determine the age of the fallout by following the decay curve of the Berkeley sample as soon as the high radiation level was detected. It was decided not to make similar studies on other samples because it was presumed that increased fallout at other stations resulted from the same event.

Air data for all 14 stations from December 30 through January 5 are shown in table 1. Daily data depicted at those stations that had a composite sample for the New Year weekend, i.e., from 0800, December 30, 1966, to 0800, January 3, 1967, were estimated by proportioning the total 4-day fallout in the same ratio as for the four known stations.

As stated previously, four stations in the California air network change samples daily. The other 10 stations remove filters only on workdays. These 10 stations, over weekends and holidays, collect samples representing 2, 3

Table 1. Gross beta radioactivity in air, December 1966-January 1967 (pCi/m³)^a

Sampling station	December 1966		January 1967				
	30	31 ^b	1 ^b	2 ^b	3 ^b	4	5
Bakersfield	0.1	0.1	0.2	14	39	5.0	0.7
Barstow ^c	.1	.1	.1	18	36	7.3	4.2
Berkeley ^c	.1	.7	16	98	38	1.5	.5
Truman Summit	.1	.3	4.0	42	34	2.4	.1
El Centro	.1	.1	.1	21	42	9.2	3.4
Eureka	.1	.4	4.6	49	39	1.2	.2
Fresno	.1	.1	.1	.1	.1	1.4	.6
Los Angeles	.1	.1	.1	22	42	2.5	1.6
Modesto	.1	.1	2.2	23	19	3.1	.4
Sacramento ^c	.1	.1	.2	47	98	3.3	2.2
Salinas	.1	.1	1.2	13	19	8.0	1.8
San Bernardino	.1	.1	.1	1.3	2.6	5.9	7.7
San Diego	.1	.1	.1	3.3	6.7	7.9	1.1
Santa Rosa ^c	.1	.1	.5	43	10	2.2	1.8
Station average	0.1	0.2	2.8	35	28	4.4	1.9

^a The error in beta air particulate analysis is approximately ± 0.1 pCi/m³ at the 95-percent confidence level.

^b Values shown in columns, December 31, January 1, 2, and 3 are analyses of daily filter samples for only 4 stations; i.e., Barstow, Berkeley, Sacramento, and Santa Rosa. All other data for those 4 days are calculated from a 4-day composite as described in the text.

or 4 days. Debris from the December 1966 test arrived in the middle of a 4-day air sample. Thus, each of the 10 stations indicate a single radiation level accumulated for the 4 days although it is known that the increased level did not occur until the last 2 days.

The method used to calculate the probable gross beta air levels for the 4 days of continuous sampling for the 10 stations is illustrated in table 2. Barstow was used as the model for southern California. Barstow's air levels were as shown in column 1 with the 4-day total at the bottom. The percent was calculated by dividing each of the 4 days by the total. The Los Angeles air sample was a 4-day sample with a total gross beta radioactivity of 63.6 pCi/m³. The calculated Los Angeles air levels were obtained by multiplying 63.6 by the percent in column 2.

Table 2. Calculations of gross beta radioactivity in air for Barstow and Los Angeles (concentration in pCi/m³ and percent per day)

Barstow		Los Angeles
Air levels	Percent	As calculated
0.1	0.2	0.1
0.1	0.2	0.1
18.5	34.0	21.6
35.7	65.6	41.8
54.4	100.0	63.6

For northern California, gross beta radioactivity data from Santa Rosa, Sacramento, and Berkeley were used to establish the ratio for calculating Eureka, Redding, and Salinas values. Data for calculating Eureka fallout are shown in table 3.

Table 3. Calculation of gross beta radioactivity in air in northern California (pCi/m³)

Berkeley	Santa Rosa	Sacramento	Total	Percent	Eureka Calculated
0.7	0.1	0.1	0.9	0.3	0.3
16	0.5	0.2	16.7	4.8	4.4
98	43	47	188.0	53.4	49.1
36	10	98	146.0	41.5	38.2
152.7	53.6	145.3	351.6	100.0	92.0

The levels measured on these samples indicated some of the highest gross beta fallout radioactivity ever detected by our network.

The previous highs occurred during the intensive testing by the United States and Russia in the fall of 1962. On November 6 and 8, 1962, during that series, Donner Summit and San Bernardino had measured air concentrations of 108 and 192 pCi/m³, respectively, and on November 25, 1962, Berkeley and Santa Rosa had 94 and 99 pCi/m³, respectively. These quantities were the result of many nuclear tests; 20 in October 1962 and 9 in November 1962. The levels were high, the duration of the peak was short. Figure 2 shows the daily statewide average air radioactivity levels during the 1967 fallout incident. Each peak in figure 2 covers about 5 days, however, air levels did not return to normal, less than 0.5 pCi/m³, until March.

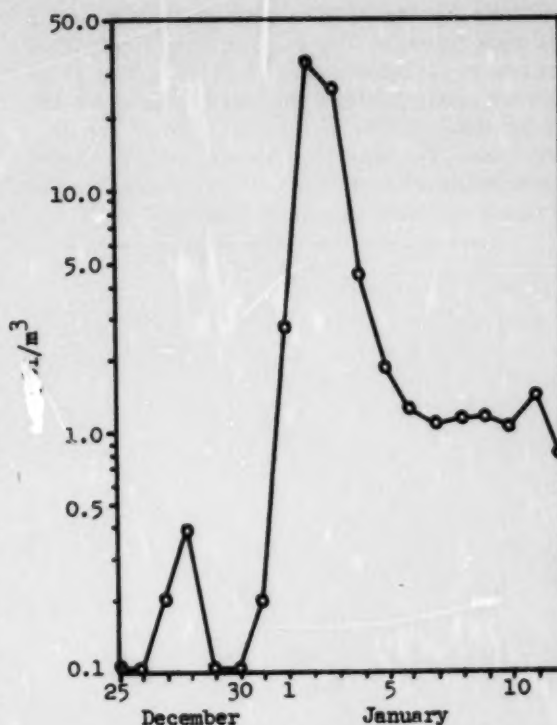


Figure 2. Radioactive air levels in California network averages, December 1966 and January 1967

The Berkeley sample removed January 2, 1967, was counted 12 times over a period of 36 days to obtain data for plotting a decay curve. The data shown in table 4 are plotted in figure 3 on special graph paper that is used

Table 4. Analysis of Berkeley air sample obtained on January 2, 1967

Date analysed (1967)	Days after first analysis	Radioactivity (pCi/m ³)	Radioactivity adjusted for plotting ^a (pCi/m ³)
January 3	0	144	72
6	3	98	49
7	4	85	43
9	6	56	28
11	8	39	20
13	10	30	15
16	13	30	15
20	17	24	12
26	22	19	10
30	27	16	8
February 3	31	14	7
8	36	12	6

^a Column divided by two so that the data will be more amenable.

for determining the age of mixed fission products (3). It is constructed by letting time be the abscissa, using a linear scale, and the radioactivity be the ordinate, using a scale which is made by evaluating one over the radioactivity raised to the 0.833 power ($1/A^{0.833}$). For mixed fission product fallout the plot is a straight line. Zero time on the plot is the day of the first analysis. The approximate age of the fallout is determined from the point at which the line crosses the abscissa, in this case 5.5 days.

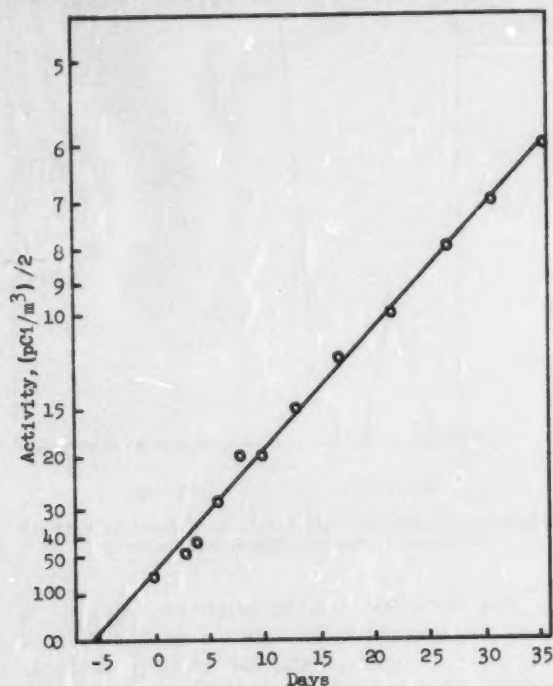


Figure 3. Decay of a Berkeley air particulate sample collected from January 1, 0800 to January 2, 0800

The age of fallout also may be calculated from an equation without using the special graph paper. Using data from table 4 and letting

T_1 = time of first analysis, January 3

A_1 = 144 pCi/m³, activity on January 3

T_2 = T_1 + 36 days, February 8

A_2 = 12 pCi/m³, activity on February 8

then solve the equation $\log(A_1/A_2) = 1.2 \log(T_2/T_1)$ remembering that $T_2 = T_1 + 36$. Solution of the problem gives $T_1 = 5.2$ days. Thus, the fallout was 5.2 days old at the time of the first analysis on January 3. This agrees very well with the results obtained from the graphical methods.

Milk network

Milk is routinely sampled monthly from ten milksheds to determine its radioactivity. Milksheds in the program are shown in figure 4. When the December 27, 1966 detonation was announced, the sampling frequency was in-

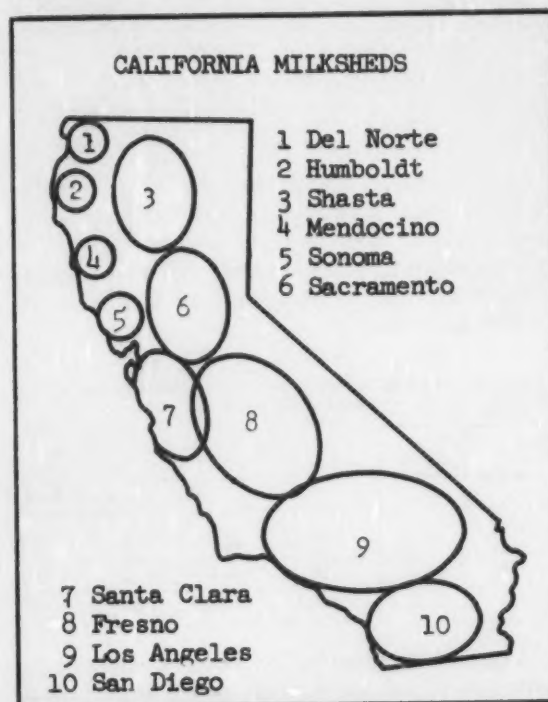


Figure 4. California milksheds

creased to daily sampling for north coastal California and to twice weekly sampling for the remainder of the network.

Analyses for iodine-131 were of prime importance for several reasons: (1) because of its short half-life, its presence is indicative of fresh fission fallout; (2) as a gamma-ray emitter having a characteristic spectrum, it can be determined rapidly; (3) it is one of the most hazardous isotopes in early fallout; and (4) because of the speed at which it can be measured, levels are used to determine the necessity of protective action. If levels become too high, recommendations can be made to convert the whole milk to powdered milk or cheese so that storage would allow the radioactivity to decay to acceptable levels. It should be emphasized that it was not necessary to take any corrective action during this incident because of any considerations including public health.

Samples from all ten milksheds showed the presence of iodine-131. Concentrations of iodine-131 in milk samples from Del Norte and Humboldt milksheds run several times higher than those found in other milksheds in California. Although there was no rain in California during the time the peak fallout cloud was over the State, some rain fell in Humboldt and Del Norte counties during the arrival and passing of the leading and trailing edges, respectively. The rains that occurred were:

Milkshed	January 1	January 4	January 5
Del Norte	0.27 inch	0.37 inch	—
Humboldt	0.08 inch	0.77 inch	0.13 inch

All other milksheds received no rain until the 19th or 20th of January. Thus, some rain-out did occur but a large portion of the pasture contamination was assumed to be through dry fallout. Also, it was assumed that the contamination originated from a single event. One may then determine the effective half-life of the iodine-131 in milk from this incident.

Several investigators have determined the apparent half-life of iodine-131 on plants and in milk. The range is from 3.0 to 6.0 days according to Thompson who further states that the same variables operate regardless of the isotope involved and are related to the behavior of particles on plants (5). For most practical

problems a useful approximation of the effective half-life of any isotope on plants is given by the following equation (5):

$$T_e = \frac{18 T_r}{18 + T_r}$$

where,

T_e is the effective half-life (days),

T_r is the radiological half-life (days), and

18 is the mean half-residence time (days).

If the radiological half-life of iodine-131 (8 days) is substituted in the equation, the effective half-life is calculated to be 4.95 or 5 days. The apparent half-life of the iodine-131 in Humboldt and Del Norte milk was determined assuming that the contamination originated from a single event and using the data given in table 5. Figure 5 shows this value to be 3.2 days for this specific detonation and under the prevailing climatic conditions.

Because of the early arrival of debris from the December 27 detonation there was some concern about the concentration of iodine-133 in the milk. This isotope has a 21-hour half-life. Since there was no analytical procedure available for its measurement, the concentration of iodine-133 was calculated from the known facts: the decay curves of iodine-131 and iodine-133; the relative activity of the two isotopes from uranium fission; and the known amount of iodine-131.

The two decay curves are shown in figure 6. Weaver, et al., estimated total chain and independent fission yields for several neutron-induced fission processes,

$$1.88 \times 10^6 \text{ Ci of } ^{131}\text{I/kiloton}$$

$$\text{For } ^{235}\text{U: } \frac{1.62 \times 10^5 \text{ Ci of } ^{131}\text{I/kiloton}}{1.88 \times 10^6 \text{ Ci of } ^{131}\text{I/kiloton}} = 11.6$$

$$1.71 \times 10^6 \text{ Ci of } ^{133}\text{I/kiloton}$$

$$\text{For } ^{239}\text{Pu: } \frac{1.38 \times 10^5 \text{ Ci of } ^{131}\text{I/kiloton}}{1.71 \times 10^6 \text{ Ci of } ^{133}\text{I/kiloton}} = 12.4$$

$$1.38 \times 10^5 \text{ Ci of } ^{131}\text{I/kiloton}$$

It was assumed that the activity ratio of iodine-133 and iodine-131 formed in the detonation was 12 to 1 (6). Figure 6 reflects this assumption in that iodine-131 at zero time was plotted as 100 and iodine-133 as 1200. Plotted in this manner, the relative amounts of the two isotopes can be selected from the graph for any given day.

Table 5. Iodine-131 in California milk, January 1967* (concentration in pCi/liter)

Date 1967	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma
January 3	4	(b)	63							14
4						0		21		
5		13	272					13	30	
6	297		280	30	15	41	15			35
7			190							32
8			116							31
9			78							
10	95	48	51		12	10		30	25	32
11	104		62	10	4					25
12			86		10					4
13	35	28	43	17	3	15	3	17	19	8
14			44		13					15
15										
16	87		34		12					
17			34		7					
18	41		30	5						
19			11		13					2
20	37		36		3					12
21					9					21
22										
23	19		0							
24	12							0		
25										
26										
27	1		0	0						18

* The error in the iodine-131 analysis in milk is approximately ± 7 pCi/liter at the 95-percent confidence level.

* Blanks indicate no sample received.

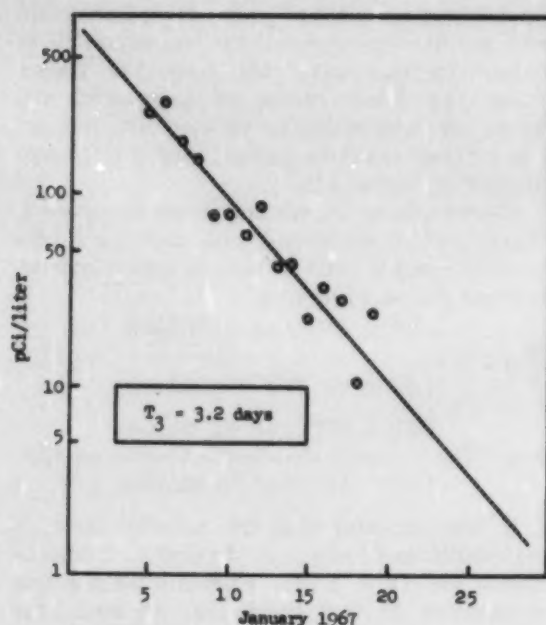


Figure 5. Humboldt milk data Iodine-131 from foreign nuclear test, December 27, 1966

The Humboldt milk maximum iodine-131 concentration occurred on January 6, only 10 days after the detonation. Using figure 6, the relative amounts of the two isotopes on that day were 0.40 for iodine-133 and 42 for iodine-131, roughly 1 to 100. Therefore, since the Humboldt peak for iodine-131 was 280 pCi/liter, the iodine-133 concentration would be approximately 3 pCi/liter. From such calculated concentrations iodine-133 was considered to have little significance to health in this incident.

It then became important to estimate the dose resulting from drinking the milk. For the purpose of this estimation, the method used by Knapp was employed (7). It was assumed that a child had a thyroid of 2 grams (M); drank 1 liter of milk per day (L) with an incident concentration of 1 pCi iodine-131/liter of milk (400 pCi for Del Norte and 280 pCi for Humboldt); and that the fraction (F) of ingested iodine-131 taken up by the thyroid gland was 0.3. Accordingly, the dose from the fallout deposition in Del Norte and Humboldt

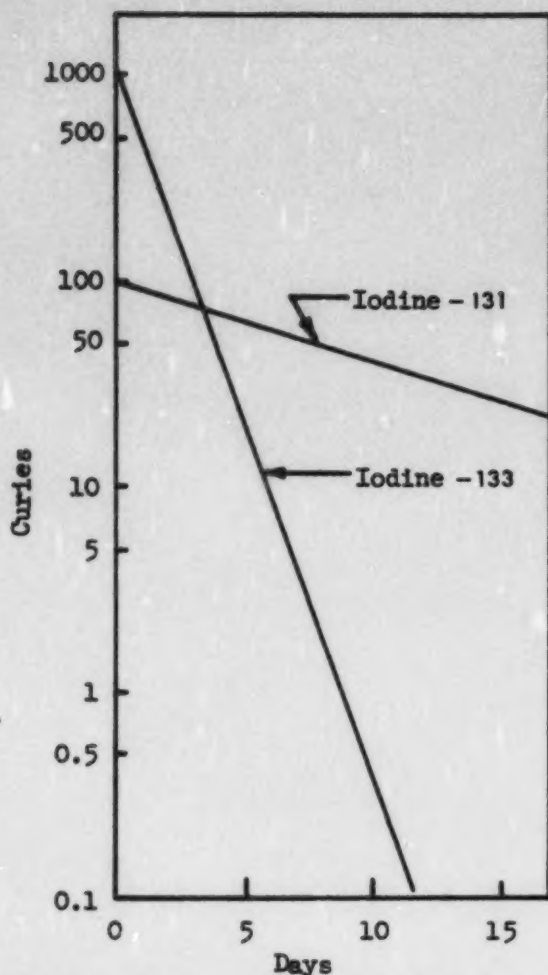


Figure 6. Decay curves for iodine-131 and iodine-133

were estimated as follows, using T_1 equal to 3.2 as already determined:

Dose in rads — $(1.71 \times 10^4) \text{ LFI}_1 T_1 / M$; hence
 Del Norte dose — 0.033 rads, and
 Humboldt dose — 0.023 rads

For Del Norte and Humboldt children, the estimated total dose to their thyroids from the deposition was 33 millirads and 23 millirads, respectively, if they drank a liter of milk per day.

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A Comparison of Results Between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 Through June 1966

Paul B. Robinson¹

The Public Health Service Raw Milk and Pasteurized Milk Networks are compared for the interval January 1964 through June 1966 on the basis of milk sample analyses made during that period. Once laboratory effects due to analytical differences in the milk sample analyses were removed from the data, the agreement for cesium-137 and strontium-90 between four of the nine stations that were common to both networks was related to milkshed overlap. At two other stations, Cincinnati and Chicago, homogeneity in the agricultural, geographical, and meteorological parameters accounted for the similarity between the sample concentrations of cesium-137 and strontium-90. It was not possible to study iodine-131, barium-140, or strontium-89 because the levels were generally not detectable for the period under study.

A tabulation of data for all samples collected from the Raw Milk Network is also appended for the period, January 1963-December 1966.

In May 1957, the Raw Milk Network (RMN), operated by the Milk and Food Research Program of the Division of Environmental Engineering and Food Protection² and funded by the Division of Radiological Health³, commenced operation. This surveillance program represented a first attempt to monitor the intake of radionuclides in the diet of people through milk sampling of milksheds serving metropolitan areas. Milk was chosen because it is produced throughout the year and was an integral part of the diet of children and young adults. Its uniform composition and continuous use made possible the development of analytical techniques for handling large numbers of samples on a routine basis. Milk and milk products are major contributors of strontium-90 and iodine-131 in the diet.

Nine RMN stations had collected samples

regularly from August 1958 until the cessation of the network in December 1966. A tabulation of the monthly results for the milk analyses in the RMN is given in Appendix I for the period, January 1963 through December 1966.

It was possible to make a comparison at each station for those Raw Milk Network and Pasteurized Milk Network (PMN) analyses made at the Northeastern, Southeastern and Southwestern Radiological Health Laboratories (NERHL, SERHL, and SWRHL, respectively) for the period, January 1964 through June 1966. This comparison was facilitated because of the availability of quality control data for all three laboratories, and the fact that all raw milk analyses were performed at a single laboratory (SWRHL). Each single monthly RMN sample was compared with that weekly PMN sample most closely related in time. Occasionally two weekly PMN samples straddled the RMN sample equidistantly in time. When such was the case, the average of those data was used in the comparison. A similar summary was undertaken by Campbell (1) for the Raw Milk Network results from 1957-1963, however, extensive quality control data were not available for that period.

¹ Mr. Robinson was staff officer, Radiation Exposure Intelligence Section, Standards and Intelligence Branch, National Center for Radiological Health, Rockville, Md. and is presently a member of the technical staff at the Bell Telephone Laboratories at Holmdel, N. J.

² Presently part of the National Center for Urban and Industrial Health, Environmental Control Administration.

³ Presently the National Center for Radiological Health, Environmental Control Administration.

Raw Milk Network sampling program

Once a month in each of nine milksheds⁴, a 1-gallon sample of raw milk was taken from a group of farms selling to one of the dairies supplying the station with pasteurized milk. This sample represented a 1-2 day composite of the milk produced on these farms.

The farms were chosen to satisfy four criteria (2,3):

- (1) the milk represented in each sample was from a group of farms milking a total of at least 1,000 cows.
- (2) the number of individual farms was small enough so that collection of collateral farm data from each farm was feasible.

⁴ For purposes of this paper, raw milk milkshed areas are defined as a county or group of counties having at least one farm which regularly sells raw milk to a dairy processing plant that supplies pasteurized milk to a RMN-PMN station city.

(3) the milk samples were from a supply that was part of a metropolitan milkshed.

(4) the conditions under which the milk was received were such that each sample was representative of the same farms in the production area.

Wherever possible, the group of farms that were chosen were located along a tank-truck route or a can-truck route. In this case the milk sample would be representative of a 1-day supply. It normally took 1 to 2 days to separately sample each form.

The introduction of the PMN made possible the collection of a weekly composite sample of pasteurized milk which was representative of from 80 to 100 percent of the milk sold at each of the nine stations. Figure 1 presents qualitatively the RMN-PMN relationship.

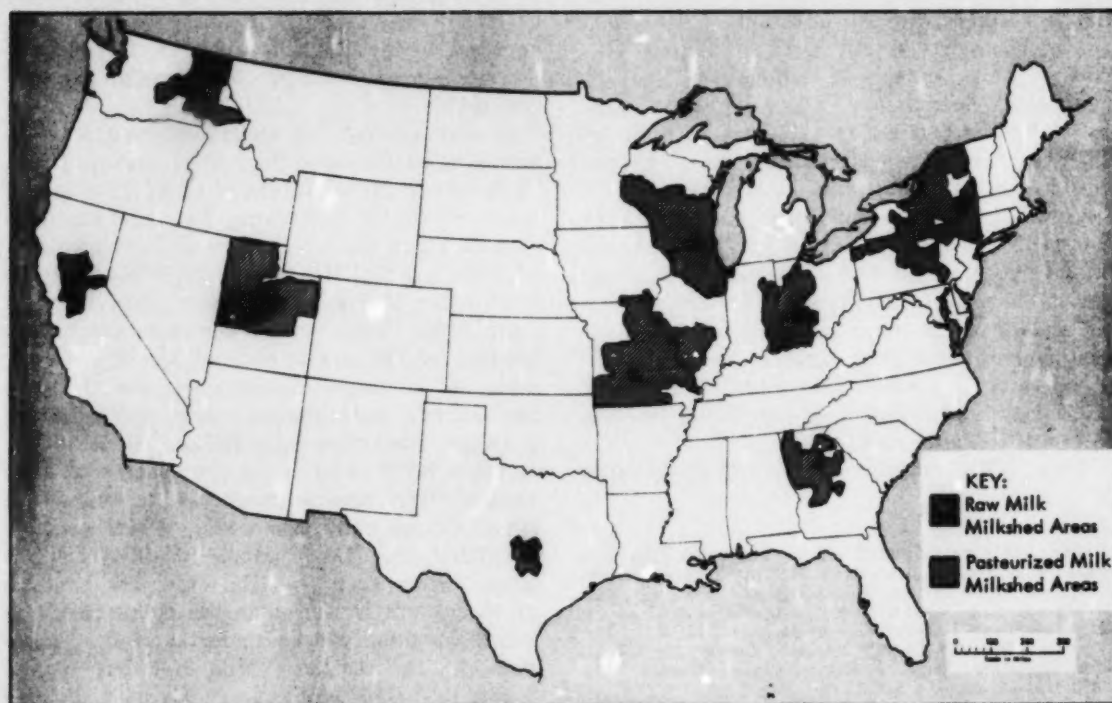


Figure 1. Outlines of RMN-PMN milkshed areas

Procedure

In order to compare the RMN with the PMN on the basis of their sampling schemes, it was necessary to consider any differences which might be present in the data due to the fact that various laboratories were involved in analyzing the samples. The analytical cross-check data, as collected monthly by the Analytical Quality Control Service (AQCS), National Center for Radiological Health (4), furnished this information.

During the study period from January 1964-June 1966^a all raw milk samples were analyzed at SWRHL. The PMN analyses were performed on a regional basis with NERHL analyzing milk from Chicago, New York City, and Cincinnati; SERHL analyzing milk from Austin and Atlanta; and SWRHL analyzing milk from Sacramento, Spokane, Salt Lake City and St. Louis.

Adjustment of RMN and PMN data for laboratory effects

Through the auspices of the AQCS program, identical pasteurized milk samples with unknown concentrations of radionuclides are analyzed in triplicate at each of the three regional laboratories. This program is carried out on a monthly basis. Under the assumption that all laboratories share the same degree of internal reproducibility (4), the three replicate measurements of each laboratory are averaged and the range of the several laboratory means is calculated. Given that the variance of each average is known, a range control chart (4) can be designed to test the null hypothesis, $H_0: \mu_1 = \mu_2 = \mu_3$, against the alternative hypothesis, H_1 : the means μ_i are not equal (4), where μ_i ($i = 1, 2, 3$) are the sample means for each laboratory.

These monthly crosscheck data were utilized to search for and define laboratory effects in the PMN and RMN radionuclide analyses. An estimate of these effects was necessary to properly compare the two networks solely on the basis of their sampling plans.

^a The strontium-90 RMN-PMN comparisons cover the time interval, January 1964-December 1966. Calcium analysis was discontinued in March 1966.

In most cases, more than the three regional laboratories participated in these monthly crosscheck programs. Thus, with results from four or five laboratories, it was possible to estimate the concentration of each radionuclide from each month's crosscheck data, by first removing results which were statistical outliers based on the range of the results from the laboratories, and then using the average of the remaining data as an estimate of the concentration.

When an outlying value was found, it was dropped from consideration and a new range and control limits were calculated. This process was continued until some noncritical subset of laboratories participating in the crosscheck was found. This subset contained two or more laboratories whose range did not exceed the control limits. The average concentration of this subset was used as a "best" estimate for the true concentration for the particular radionuclide in the crosscheck sample. When a range was found out of control with no laboratory appearing as an outlier, a search was made of succeeding monthly samples to detect any trend (i.e., some laboratory whose results were generally above or below the values from other laboratories). If such a trend developed, that laboratory was said to be out of control for the crosscheck period and removed from further consideration. Many times it was impossible to reduce a range to a noncritical state. When such a case occurred, an estimate of the true concentration was taken as the average of all the laboratories.

From a compiled listing of these "best" estimates, a measure of the monthly bias in the nuclide determinations at each regional laboratory was computed. For the radionuclides, an incorrect calibration in the counting instruments will lead to bias which is a function of the radionuclide concentrations present. For example, the beta-particle counting of strontium-90 using an incorrect efficiency will yield a bias which is proportional to the true concentration. In gamma-ray spectrographic analysis, the bias and gain shifts yield errors which are functionally related to the interfering radionuclides and background levels. For the purpose of relating quality control data to the bias in a routine operation, the assump-

tion was that bias is proportional to the true concentration of the radionuclide being assayed. This same assumption was used for calcium determinations. However, since the calcium levels in milk are relatively invariant, a constant bias and a constant percent bias are almost identical in this case.

For the purpose of obtaining data correction factors, least square polynomials were fitted to the bias estimates for each laboratory and each nuclide under study. From these curves estimates of the average bias for each month were obtained. Table 1 shows the resultant correction formulae obtained from this analysis. RMN and PMN data corrected for laboratory effects appear in figures 2-5.

Table 1. Correction factors for laboratory differences between the Raw Milk and Pasteurized Milk Networks

Nuclide	Laboratory	Error function
Cesium-137	SERHL	$p(t) = 98.3462 - 0.0970t - 0.0135t^2$
	SWRHL	$p(t) = 96.5939 - 0.0493t$
	NERHL	$p(t) = 104.2333 - 0.1959t + 0.0100t^2$
Strontium-90	SERHL	$p(t) = 101.6792 + 0.0320t + 0.0233t^2$
	SWRHL	$p(t) = 112.3912 + 0.7210t$
	NERHL	$p(t) = 95.5769 + 0.0062t$
Calcium	SERHL	$p(t) = 90.1142 - 0.0223t - 0.0036t^2$
	SWRHL	$p(t) = 106.6730 + 0.2468t - 0.0132t^2$
	NERHL	$p(t) = 98.1115 - 0.0204t + 0.0074t^2$
Potassium	SERHL	$p(t) = 99.2044 + 0.0825t + 0.0117t^2$
	SWRHL	$p(t) = 99.8155 - 0.2679t - 0.0304t^2$
	NERHL	$p(t) = 101.1462 - 0.1328t$

* $p(t) = 100 \left[\frac{\text{estimated mean concentration}}{\text{true mean concentration}} \right]$, where t = time in months with $t = 0$ at July 1965 and $(-18 \leq t \leq 17)$.

Summary of results

Paired t-tests for the corrected RMN and PMN data from each of the nine stations (table 2) yielded results which for strontium-90 are similar to those of Campbell (1), with significant differences observed at New York City, St. Louis and Atlanta. For cesium-137, New York City and St. Louis showed significant differences in the mean concentrations. In the case of the stable elements, potassium and calcium, the only significant difference shown by this test was observed for calcium at Atlanta.

Table 3 presents correlation coefficients for the concentration of the various elements and radionuclides for each of the data sets. An analysis of table 3 shows that for strontium-90 and cesium-137 significant correlations exist between the two networks with the higher correlations consistently associated with cesium-137. During the period of comparison, January 1964-June 1966, when fallout levels were decreasing, direct absorption of cesium-137 by plants would amount to a greater degree of plant contamination than would uptake through the soil. The opposite would be the case for strontium-90 (?). Therefore, cesium-137 would be expected to be less affected by farming practices than strontium-90.

Calcium correlations were all insignificant. This may be interpreted to mean that labora-

Table 2. Paired t-test^a results for internetwork comparison of mean concentrations

Nuclide	New York City	Cincinnati	St. Louis	Salt Lake City	Sacramento	Atlanta	Chicago	Spokane	Austin
Strontium-90	b-5.91	-0.66	b 10.34	-1.93	2.45	b 4.92	3.09	-2.09	0.53
Cesium-137	b-6.27	.41	b 5.34	-1.92	1.94	-1.15	1.55	0.42	1.51
Potassium	-0.45	-.60	-3.06	-1.22	-0.55	0.72	-0.96	.85	1.98
Calcium	2.10	.72	3.66	-1.10	1.00	4.27	.55	-.65	.31

^a Two-tailed test at 0.002 level of significance for each individual t-test, with degrees of freedom equal to $n-1$, where n is the number of paired samples for a particular radionuclide at a specific station (see figures 2-5 for values of n). For the entire set of 36 t-tests, the probability of a type I error is 0.07.

^b Significant differences.

Table 3. Correlation coefficients^a for the two networks at each station

Nuclide	New York City	Cincinnati	St. Louis	Salt Lake City	Sacramento	Atlanta	Chicago	Spokane	Austin
Strontium-90	0.80	0.84	0.71	0.63	0.63	0.84	0.79	0.84	0.58
Cesium-137	.97	.94	.95	.79	.86	.91	.93	.96	.65
Potassium	.33	.06	.56	.03	.40	.63	.62	.28	.27
Calcium	.09	.29	.22	.03	.22	.39	.24	.26	.10

^a To test whether p (correlation coefficient) is significantly different from zero given the tabled value of r (observed correlation coefficient) for a sample size of 30 at $\alpha = 0.002$, we have as critical points $r_{0.002, 28} \approx \pm 0.54$. Hence for $|r| \geq |r_{0.002, 28}|$ we can assume $p \neq 0$. For the entire set of 36 t-tests the probability of type I error is 0.07.

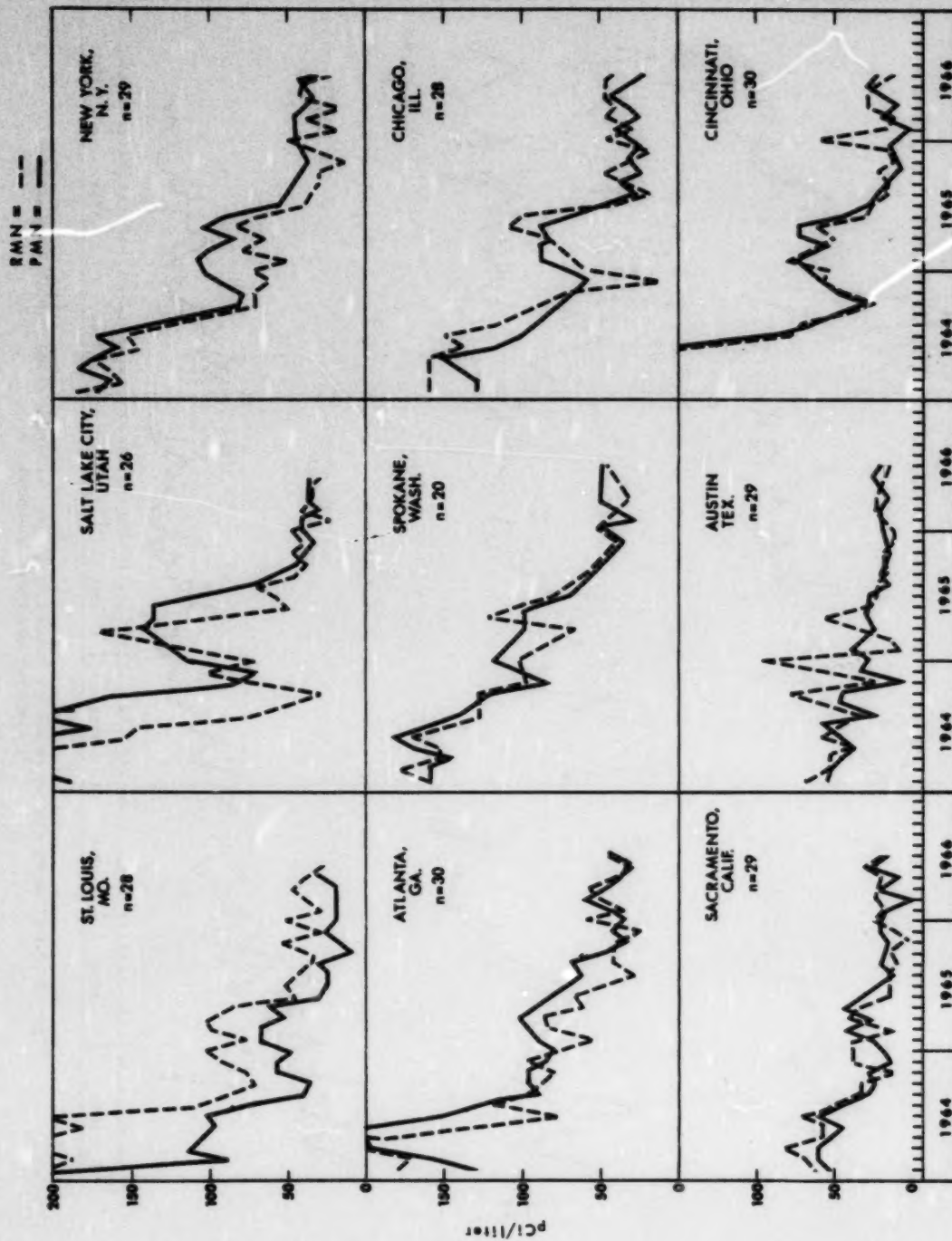


Figure 2. Cesium-137 data corrected for laboratory effects^a n=number of paired RMN-PMN samples
^aUnadjusted data given in Appendix 1

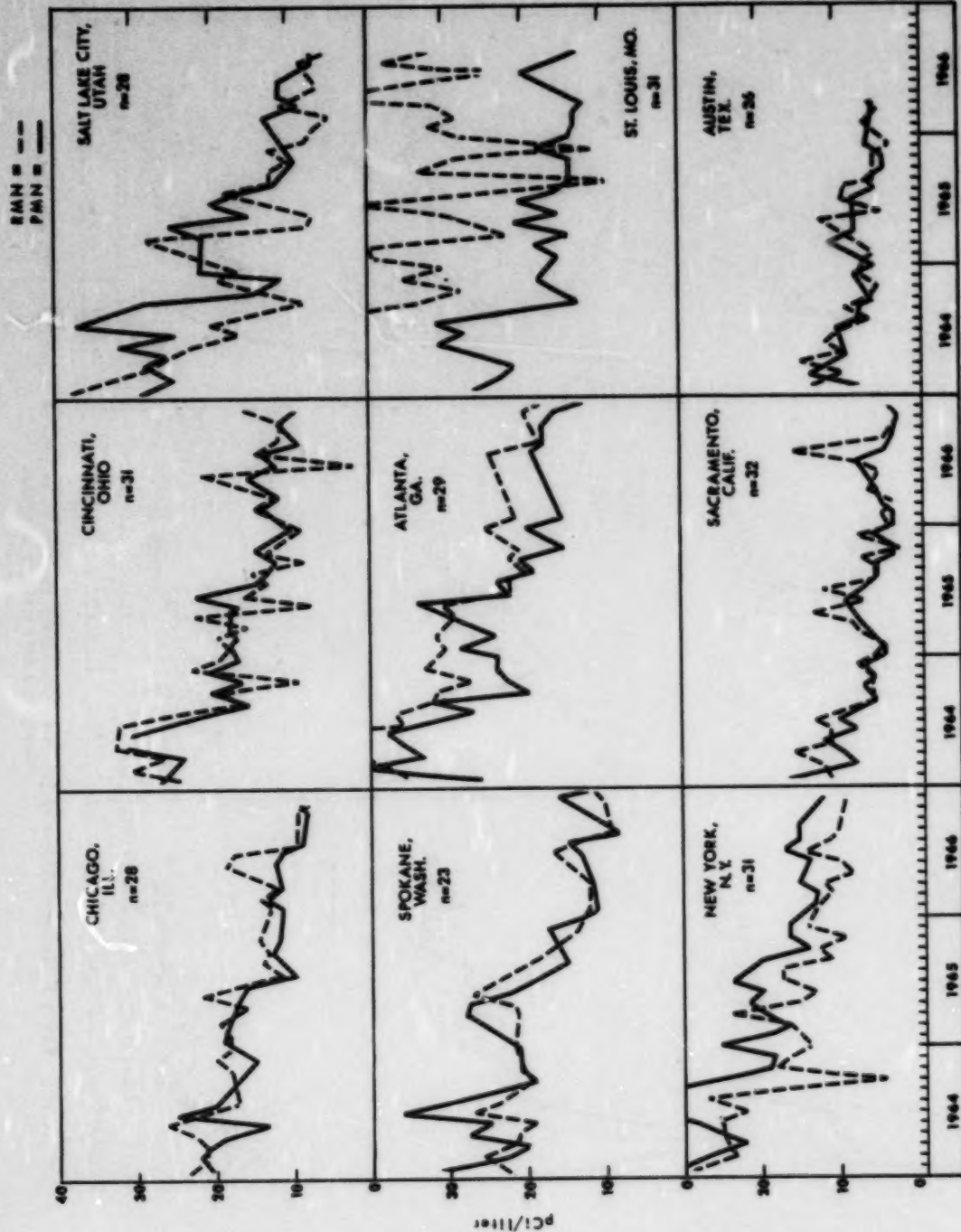


Figure 3. Strontium-90 data corrected for laboratory effects* n=number of paired RAN-PAN samples
 *Unadjusted data given in Appendix 1

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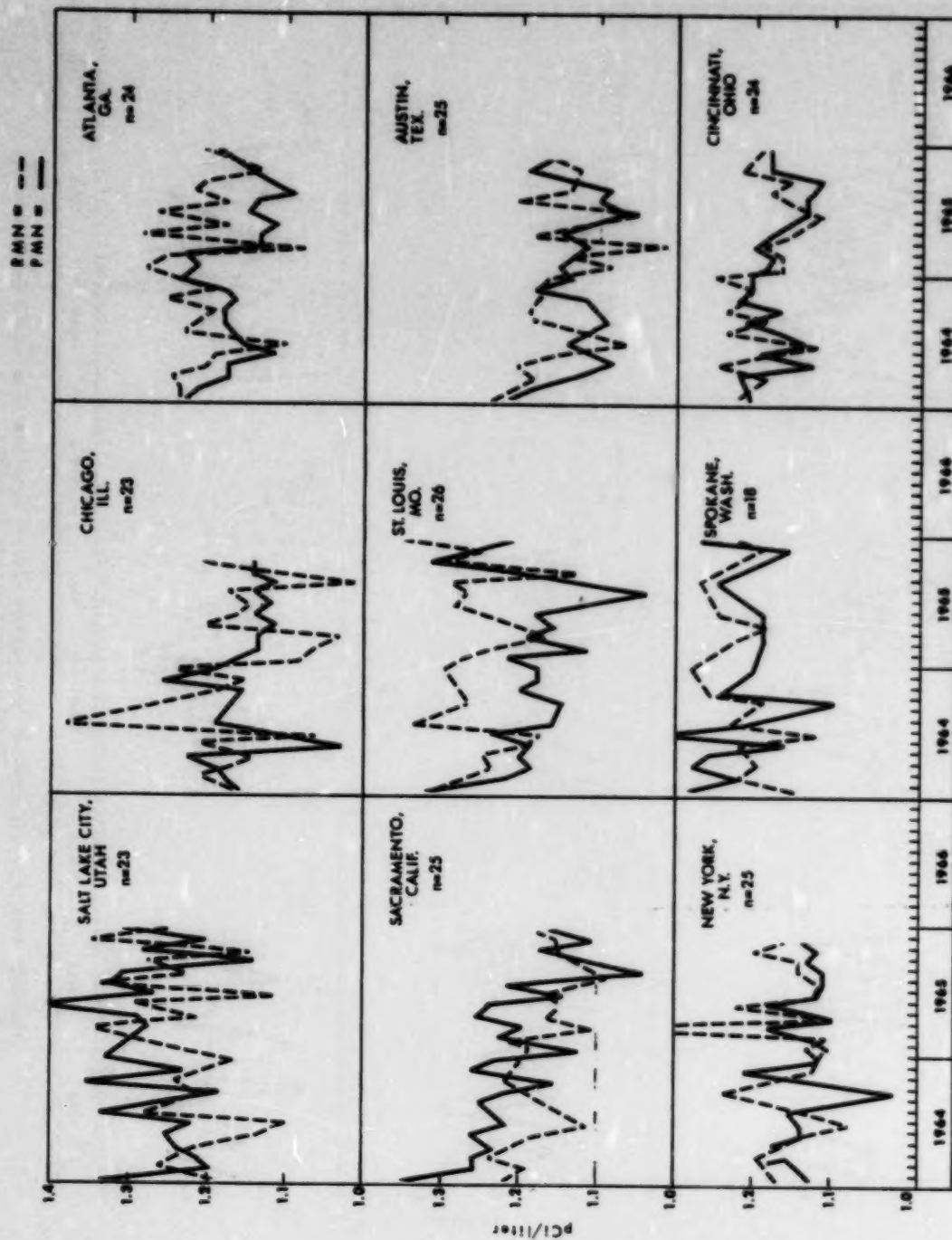


Figure 4. Calcium data corrected for laboratory effects^a. n=number of paired RMN-PMN samples
^aUnadjusted data given in Appendix 1

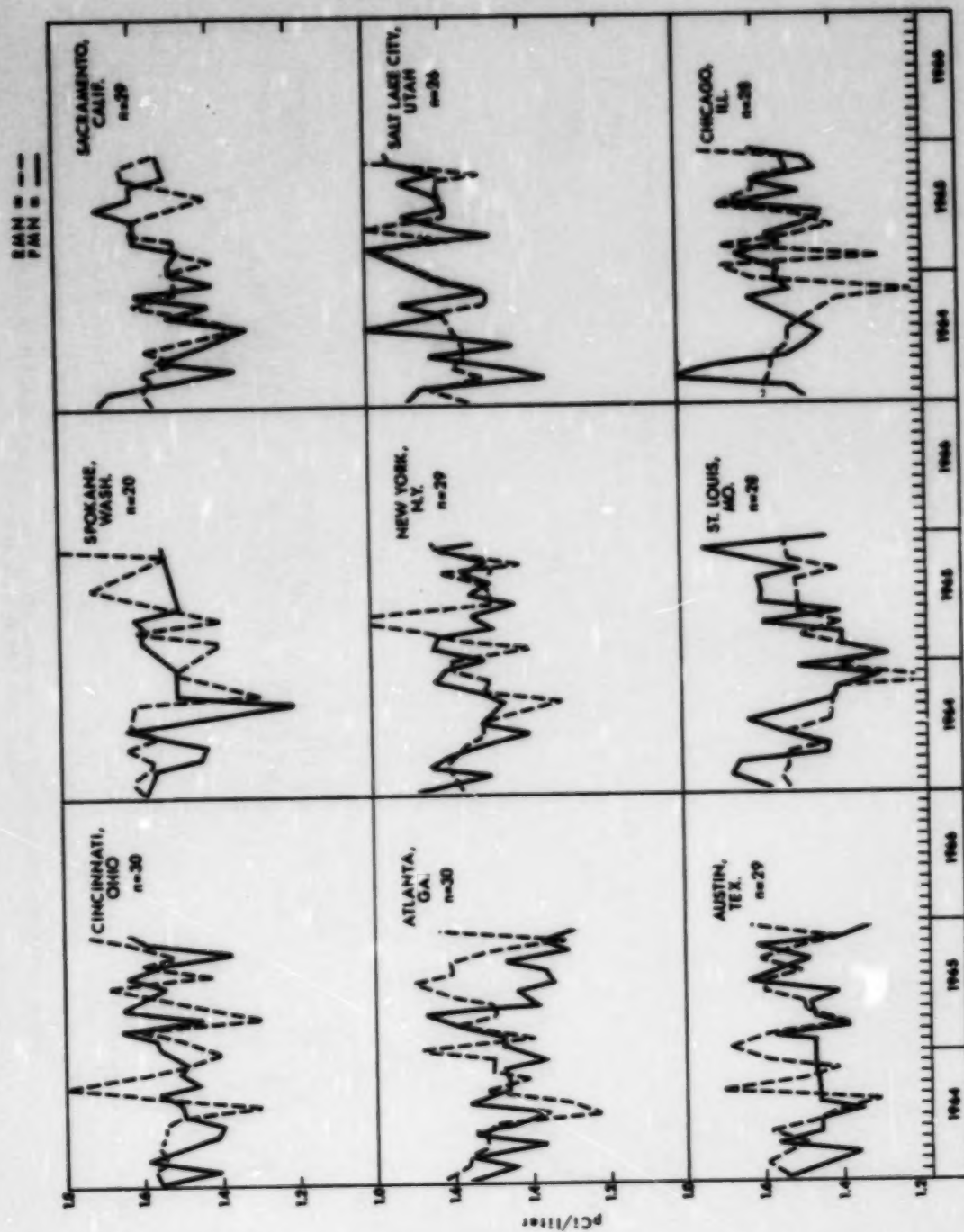


Figure 5. Potassium data corrected for laboratory offset. n=number of paired RMN-PMN samples
 *Unadjusted data given in Appendix 1

tory analytical errors and sampling errors are greater than changes in the concentration levels. Similar results were observed for potassium with evidence of some correlation existing in St. Louis, Atlanta, and Chicago.

Conclusions

At four stations, where results obtained from the two milk sampling programs were similar, as is evidenced by the lack of significant differences in the mean concentrations (table 2) and the higher correlations in table 3 for strontium-90 and cesium-137, a greater degree of geographical overlap (figure 1) was found between the RMN and PMN milksheds than among the other stations. For these four cities, Salt Lake City, Sacramento, Austin, and Spokane, the raw milk sample is probably more representative of the PMN sample than for the other cities.

At two other stations, Cincinnati and Chicago, evidence was also found of correlation between the networks for cesium-137 and strontium-90 and a lack of significant differences in the paired t-tests for the mean concentrations of the elements and radionuclides studied. However, as can be seen in figure 1, these stations have little milkshed overlap. A plausible explanation of this apparent paradox lies in the relationship of farming practices, soil fertility, and rainfall between the RMN and PMN counties. Olsen (8) shows that these RMN milksheds normally have cows on pasture from May 1 to October 1, and that these dates can be extended to the PMN milksheds with the exception that the dates extend from April 1 to October 15 and May 15 to September 15 for Cincinnati and Chicago, respectively. Rainfall over this entire five-State area is fairly uniform and a survey of the farms at each milkshed that participate in the RMN shows a high degree of similarity as far as farming practices are concerned. Hence, it seems reasonable that each RMN milkshed is representative of the greater PMN milkshed due to the homogeneity of the important factors. Therefore, on this basis, it is not unreasonable to expect to see similarity in the levels of the elements and radionuclides studied.

In New York City, St. Louis, and Atlanta, where there was evidence of significant differences in the mean concentrations of various radionuclides and elements, the RMN and PMN milksheds had in common an extremely small geographical area. In New York City and St. Louis, the RMN sample was representative of only one out of 30 and one out of 26 dairies, respectively; and in Atlanta, one out of 4 dairies.

No attempt was made to do an internetwork comparison of the milk concentrations of iodine-131, barium-140, and strontium-89 because of the extremely low levels present during the period of this study.

Acknowledgment

The author expresses his appreciation to Mr. Loren Zelsman of the Standards and Intelligence Branch staff, National Center for Radiological Health, for his help in reducing and analyzing the data.

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Appendix I

Discussion and tabulation of findings for the Raw Milk Network, January 1963–December 1966

The values for all monthly samples collected in the Raw Milk Sampling Program from January 1963 through December 1966 are summarized in tables 4 through 10 for iodine-131, barium-140, strontium-89, strontium-90, cesium-137, calcium and potassium, respectively.

A tabulation for the period 1957–1963 has been published earlier (1).

During 1963 there was a rapid decline in values for the short-lived radionuclides. However, by 1966, a decline in nearly all radionuclides was observed with only seasonal variations and slight effects due to the limited atmospheric tests in 1964.

From 1963–1966, the monthly average for iodine-131 at most stations was low or at the

Table 4. Concentrations of iodine-131 in raw milk, January 1963–December 1966

Month	Concentrations (pCi/liter)								
	New York City	Atlanta	Chicago	Cincinnati	St. Louis	Austin	Salt Lake City	Sacramento	Spokane
1963									
January.....	<10	15	<10	<10	20	40	<10	<10	<10
February.....	<10	10	<10	<10	<10	<10	<10	<10	<10
March.....	<10	<10	<10	<10	<10	<10	15	<10	10
(*)									
1964									
June.....	<10	<10	<10	50	<10	<10	<10	<10	<10
July.....	<10	<10	<10	<10	<10	<10	30	<10	—
August.....	<10	<10	<10	<10	<10	<10	<10	<10	<10
September.....	<10	20	<10	<10	<10	<10	10	10	—
(*)									
1965									
May.....	<10	<10	<10	<10	<10	<10	<10	<10	10
June.....	<10	20	20	<10	—	<10	10	<10	<10
July.....	<10	30	<10	<10	<10	—	<10	<10	<10
August.....	<10	<10	<10	<10	10	—	<10	<10	<10
September.....	<10	<10	<10	—	—	<10	<10	<10	<10
October.....	<10	<10	<10	<10	—	—	—	<10	<10
November.....	<10	<10	<10	<10	—	<10	—	<10	<10
December.....	<10	<10	<10	<10	—	—	—	<10	<10

* All intermediate data were <10 pCi/liter.

Table 5. Concentrations of barium-140 in raw milk, January 1963–December 1966

Month	Concentrations (pCi/liter)								
	New York City	Atlanta	Chicago	Cincinnati	St. Louis	Austin	Salt Lake City	Sacramento	Spokane
1963									
January.....	<10	10	<10	<10	<10	<10	<10	<10	<10
(*)									
1966									
June.....	<10	20	<10	<10	—	<10	<10	<10	<10
(*)									
December.....	<10	<10	<10	<10	—	<10	—	<10	<10

* All intermediate data were <10 pCi/liter.

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nondetectable level. During the above mentioned period there were only 14 reports of detectable iodine-131. Data for barium-140 are similar to that for iodine-131. From 1963-1966 with the exception of two analyses, all concentrations of barium-140 were nondetectable.

During 1963, maximum concentrations of strontium-89 rose to nearly the same values

in some locations as those recorded for 1957-1959 (1). During 1964-1966, concentrations were very low or nondetectable with only one significant value of 45 pCi/liter. Peak values are usually reached during the spring and summer months.

During 1963-1966, strontium-90 maximum and minimum values were considerably higher than were those for 1957-1961 (1), with a

Table 6. Concentrations of strontium-89 in raw milk, January 1963-December 1966

Month	Concentrations (pCi/liter)								
	New York City	Atlanta	Chicago	Cincinnati	St. Louis	Austin	Salt Lake City	Sacramento	Spokane
1963									
January.....	<5	95	<5	10	90	70	<5	10	<5
February.....	<5	65	<5	<5	75	35	25	25	<5
March.....	<5	80	<5	5	130	30	<5	30	<5
April.....	<5	95	10	80	180	45	<5	180	<5
May.....	30	255	25	80	170	65	<5	135	110
June.....	80	165	95	110	240	40	100	60	
July.....	80	215	35	75	115	20	95	5	90
August.....	60	45	20	30	50	5	20	5	40
September.....	25	35	10	15	35	<5	15	<5	
October.....	<5	<5	<5	<5	10	<5	<5	<5	15
November.....	10	<5	<5	5	5	<5	<5	<5	<5
December.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
1964									
January.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
February.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
March.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
April.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
May.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
June.....	5	<5	<5	<5	<5	<5	<5	<5	<5
July.....	5	<5	<5	<5	5	<5	<5	<5	<5
August.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
September.....	<5	<5	10	<5	<5	<5	<5	<5	<5
October.....	<5	<5	<5	<5	10	<5	<5	<5	5
November.....	5	<5	<5	<5	5	<5	<5	<5	<5
December.....	<5	<5	<5	<5	10	<5	<5	<5	<5
1965									
January.....	<5	<5	<5	<5	5	<5	<5	<5	<5
February.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
March.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
April.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
May.....	5	<5	<5	<5	<5	<5	<5	<5	<5
June.....	<5	<5	<5	<5	25	<5	<5	<5	<5
July.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
August.....	15	<5	<5	<5	5	<5	<5	<5	5
September.....	<5	<5	5	<5	<5	<5	<5	<5	<5
October.....	5	<5	<5	<5	5	<5	5	<5	<5
November.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
December.....	<5	<5	5	5	<5	<5	5	<5	<5
1966									
January.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
February.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
March.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
April.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
May.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
June.....	10	<5	<5	<5	10	10	<5	<5	<5
July.....	5	<5	<5	<5	45	<5	<5	<5	<5
August.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
September.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
October.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
November.....	<5	<5	<5	<5	<5	<5	<5	<5	<5
December.....	<5	<5	<5	<5	<5	<5	<5	<5	<5

maximum value of 68 pCi/liter being reached in the spring of 1964.

Cesium-137 concentration trends in raw milk were similar to those for strontium-90 for the same period. During 1963-1964, concentrations of cesium-137 reached their highest values, peaking at 390 pCi/liter in the summer of

1963; declining again during 1965-1966.

Calcium and potassium measurements were rather constant during the years 1963-1966. Fluctuations in calcium and potassium data are generally ascribed to laboratory variations, as opposed to actual variations in milk concentrations.

Table 7. Concentrations of strontium-90 in raw milk, January 1963-December 1966

Month	Concentrations (pCi/liter)								
	New York City	Atlanta	Chicago	Cincinnati	St. Louis	Austin	Salt Lake City	Sacramento	Spokane
1963									
January.....	14	23	13	17	29	7	12	5	17
February.....	18	19	10	13	28	8	12	4	15
March.....	11	16	10	14	27	7	10	10	13
April.....	11	25	9	21	46	10	8	24	11
May.....	14	48	14	20	48	13	12	23	27
June.....	25	42	27	25	51	9	32	15	15
July.....	36	55	24	30	55	7	33	12	27
August.....	30	37	24	30	55	8	22	10	30
September.....	27	30	23	21	44	8	16	8	31
October.....	32	31	22	26	46	8	22	11	32
November.....	28	31	29	32	53	7	26	12	32
December.....	24	38	23	30	46	7	31	11	36
1964									
January.....	27	35	23	24	44	13	38	11	22
February.....	24	38	22	30	51	10	34	12	25
March.....	25	43	22	27	50	15	28	16	22
April.....	25	55	23	33	68	10	26	12	23
May.....	26	59	27	33	56	11	23	11	28
June.....	23	37	24	32	61	10	17	13	28
July.....	28	38	18	27	57	6	20	13	25
August.....	18	34	16	17	32	9	11	6	21
September.....	4	33	16	20	35	6	9	6	22
October.....	19	29	19	10	30	5	20	8	23
November.....	18	35	21	24	38	7	18	6	23
December.....	15	34	20	21	33	7	18	6	23
1965									
January.....	16	33	20	20	42	6	21	5	14
February.....	18	34	21	21	43	8	21	8	23
March.....	26	33	21	18	24	10	32	9	24
April.....	17	32	18	24	56	13	9	14	30
May.....	15	34	24	8	33	5	8	7	30
June.....	19	25	19	17	47	10	14	12	22
July.....	20	25	13	15	31	10	20	6	22
August.....	13	23	15	17	11	6	14	6	22
September.....	14	25	15	11	38	6	14	4	16
October.....	11	24	16	14	34	6	12	4	14
November.....	16	29	17	21	13	4	14	9	14
December.....	14	29	15	11	32	4	9	4	14
1966									
January.....	15	25	15	15	37	7	8	5	14
February.....	13	25	16	17	34	6	6	4	14
March.....	14	22	15	15	37	7	13	7	18
April.....	10	22	14	17	54	—	10	5	20
May.....	11	29	22	25	61	7	8	9	16
June.....	17	30	21	3	31	5	10	19	11
July.....	14	22	12	18	47	—	7	5	13
August.....	13	23	9	15	39	—	6	3	10
September.....	10	18	11	14	—	3	5	4	13
October.....	13	25	13	14	—	4	—	—	14
November.....	12	21	9	19	—	—	—	—	—
December.....	—	—	—	—	—	—	—	—	—

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Table 8. Concentration of cesium-137 in raw milk, January 1963-December 1966

Month	Concentrations (pCi/liter)								
	New York City	Atlanta	Chicago	Cincinnati	St. Louis	Austin	Salt Lake City	Sacramento	Spokane
1963									
January	75	85	75	75	100	30	105	35	85
February	65	80	75	60	100	30	85	35	90
March	70	85	75	65	110	30	90	45	75
April	60	100	70	65	115	60	55	120	75
May	75	265	75	70	210	70	80	145	130
June	140	245	185	105	295	85	210	85	185
July	170	290	130	110	300	80	215	60	145
August	185	185	135	95	185	35	140	85	55
September	145	130	100	65	155	45	155	75	185
October	140	135	130	110	180	45	155	70	205
November	170	145	180	110	190	45	245		
December	180								
1964									
January	180	175	155	130	230	65	235	65	155
February	165	170	155	125	185	50	240	70	175
March	180	185	155	130	300	60	230	80	160
April	170	185	155	115	305	40	230	85	150
May	145	255	135	80	180	60	155	85	145
June	150	80	145	80	305	45	145	70	135
July	115	115	115	70	110	35	75		
August	90	85	80	40	80	45	90	30	125
September	70	85	70	35	70	75	30	30	95
October	70	80	70	40	75	35	75	30	
November	80	95	10	55	90	30	100	35	100
December	70	80	50	55	100	105	75		
1965									
January	50	55	85	75	85	10		35	
February	75	85	70	70	95	15	90	30	70
March	65	90	80	80	100	30	165	35	130
April	80	60	105	55	85	50	110	35	95
May	70	65	75	35	45	35	50	30	80
June	40	45	45	30	50	30	55	30	
July	35	30	30	20	45	30	70	15	60
August	30	40	30	20	35	15	45	20	
September	30	40	45	25	35	10	40	10	
October	15	40	30	15	50	<5	45	15	40
November	30	25	20	30	30	<5	45	30	50
December	50	55	40	60	50	15	45		
1966									
January	30	35	35	20	30	15	25	15	40
February	35	30	45	15	35	20	40	35	35
March	15	55	40	30	45	30	35	30	
April	40	40	45	25	40		35	35	45
May	40	30	45	10	30	15	35	15	45
June	25	45	40	30	35	10	30	20	80
July	15	40	30	20	35		20	15	20
August	30	40	15	10	15		30	5	50
September	15	40	15	20		5	10	<5	25
October	10	30	5	5		10		10	10
November	15	30	15	10				10	25
December	10	25	15						

Table 9. Concentrations of calcium in raw milk (g/liter) January 1963-December 1966^a

Month	New York City	Atlanta	Chicago	Cincinnati	St. Louis	Austin	Salt Lake City	Sacramento	Spokane
1963									
January	1.05	1.13	1.09	1.13	1.20	1.09	1.12	1.12	1.09
February	1.06	1.16	1.09	1.13	1.19	1.11	1.14	1.14	1.17
March	1.07	1.14	1.12	1.14	1.20	1.08	1.09	1.10	1.14
April	1.05	1.11	1.08	1.09	1.18	1.06	1.07	1.11	1.10
May	1.14	1.10	1.10	1.10	1.22	1.06	1.13	1.14	1.08
June	1.11	1.17	1.17	1.17	1.30	1.09	1.16	1.14	1.10
July	1.07	1.16	1.20	1.13	1.20	1.07	1.11	1.13	1.15
August	1.04	1.08	1.09	1.14	1.23	1.11	1.13	1.14	1.15
September	1.12	1.13	1.12	1.14	1.26	1.12	1.14	1.13	1.14
October	1.15	1.14	1.12	1.17	1.22	1.14	1.12	1.13	1.17
November	1.14	1.19	1.17	1.19	1.12	1.17	1.14	1.16	1.17
December	1.14	1.20	1.14	1.21	1.23	1.16	1.16	1.19	1.22
1964									
January	1.15	1.21	1.15	1.30	1.28	1.21	1.17	1.20	1.13
February	1.16	1.22	1.19	1.19	1.26	1.19	1.24	1.18	1.30
March	1.18	1.24	1.17	1.18	1.23	1.18	1.23	1.23	1.19
April	1.17	1.21	1.15	1.25	1.25	1.21	1.22	1.24	1.21
May	1.15	1.21	1.22	1.20	1.21	1.17	1.15	1.20	1.23
June	1.09	1.19	1.07	1.19	1.19	1.08	1.12	1.13	1.14

Table 9. Concentrations of calcium in raw milk (g/liter) January 1963-December 1966-Continued.

Month	New York City	Atlanta	Chicago	St. Louis	Cincinnati	Austin	Salt Lake City	Sacramento	Spokane
1964									
July	1.14	1.26	1.53	1.26	1.36	1.14	1.30	1.20	1.25
August	1.15	1.25	1.23	1.22	1.26	1.21	1.22	1.22	1.22
September	1.28	1.23	1.30	1.26	1.31	1.22	1.25	1.22	1.22
October	1.22	1.30	1.24	1.26	1.32	1.22	1.28	1.28	1.30
November	1.17	1.25	1.20	1.26	1.34	1.23	1.47	1.26	1.26
December	1.17	1.29	1.29	1.30	1.36	1.22	1.42	1.25	1.34
1965									
January	1.18	1.34	1.14	1.23	1.34	1.14	1.36	1.25	1.27
February	1.17	1.32	1.12	1.23	1.30	1.20	1.36	1.27	1.27
March	1.44	1.14	1.10	1.26	1.23	1.08	1.43	1.17	1.30
April	1.16	1.36	1.28	1.23	1.26	1.26	1.39	1.23	1.26
May	1.30	1.26	1.24	1.22	1.32	1.17	1.38	1.22	1.32
June	1.20	1.35	1.22	1.19	1.36	1.13	1.19	1.23	1.23
July	1.20	1.26	1.25	1.24	1.36	1.29	1.43	1.28	1.28
August	1.22	1.30	1.09	1.26	1.38	1.22	1.31	1.18	1.36
September	1.22	1.30	1.21	1.24	1.21	1.37	1.37	1.23	1.23
October	1.29	1.22	1.30	1.31	1.39	1.21	1.23	1.23	1.23
November	1.25	1.31	1.23	1.24	1.35	1.25	1.45	1.24	1.28
December	1.35	1.30	1.31	1.28	1.45	1.31	1.34	1.27	1.31
1966									
January	1.37	1.33	1.21	1.31	1.34	1.18	1.30	1.54	1.33
February	1.22	1.27	1.27	1.19	1.12	1.17	1.30	1.22	1.30
March	1.19	1.28	1.19	1.19	1.22	1.10	1.38	1.28	1.30

* Calcium analysis discontinued after March 1966.

Table 10. Concentrations of potassium in raw milk, January 1963-December 1966

Month	Concentrations (g/liter)								
	New York City	Atlanta	Chicago	Cincinnati	St. Louis	Austin	Salt Lake City	Sacramento	Spokane
1963									
January	1.5	1.5	1.6	1.5	1.4	1.5	1.5	1.5	1.5
February	1.5	1.4	1.6	1.5	1.5	1.5	1.6	1.5	1.5
March	1.5	1.4	1.6	1.5	1.5	1.5	1.5	1.5	1.5
April	1.6	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5
May	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.5	1.5
June	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.7	1.7
July	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
August	1.6	1.5	1.6	1.5	1.6	1.6	1.5	1.6	1.5
September	1.6	1.4	1.5	1.5	1.5	1.5	1.5	1.6	1.6
October	1.6	1.4	1.5	1.5	1.4	1.5	1.5	1.4	1.5
November	1.5	1.5	1.4	1.5	1.5	1.5	1.5	1.4	1.5
December	1.5	1.5	1.4	1.5	1.5	1.5	1.5	1.5	1.5
1964									
January	1.5	1.5	1.5	1.5	1.4	1.5	1.5	1.5	1.5
February	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.5	1.5
March	1.6	1.5	1.5	1.5	1.5	1.5	1.4	1.5	1.5
April	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
May	1.5	1.5	1.5	1.5	1.4	1.5	1.5	1.5	1.5
June	1.5	1.5	1.5	1.5	1.5	1.4	0.9	1.5	1.5
July	1.5	1.2	1.5	1.5	1.4	1.3	1.2	1.3	1.3
August	1.2	1.3	1.2	1.3	1.4	1.7	1.6	1.4	1.6
September	1.3	1.5	1.4	1.8	1.4	1.5	1.5	1.6	1.3
October	1.5	1.4	1.2	1.6	1.1	1.4	1.5	1.5	1.5
November	1.5	1.5	1.2	1.6	1.1	1.4	1.5	1.5	1.5
December	1.6	1.5	1.6	1.5	1.4	1.6	1.6	1.5	1.5
1965									
January	1.6	1.7	1.7	1.4	1.3	1.7	1.5	1.5	1.5
February	1.4	1.4	1.3	1.5	1.4	1.6	1.6	1.4	1.4
March	1.6	1.6	1.7	1.6	1.5	1.4	1.8	1.5	1.5
April	1.7	1.5	1.5	1.3	1.4	1.5	1.6	1.5	1.6
May	1.9	1.5	1.4	1.4	1.5	1.5	1.8	1.6	1.4
June	1.5	1.6	1.5	1.5	1.5	1.6	1.6	1.6	1.5
July	1.5	1.7	1.7	1.7	1.5	1.6	1.6	1.5	1.5
August	1.5	1.6	1.6	1.4	1.5	1.5	1.6	1.4	1.7
September	1.6	1.6	1.6	1.6	1.4	1.6	1.6	1.5	1.5
October	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.6
November	1.6	1.3	1.5	1.6	1.5	1.4	1.7	1.6	1.5
December	1.6	1.6	1.7	1.7	1.5	1.6	2.0	1.5	1.8
1966									
January	1.5	1.6	1.6	1.5	1.4	1.5	1.5	1.5	1.6
February	1.4	1.2	1.5	1.3	1.2	1.5	1.6	1.3	1.3
March	1.3	1.0	1.3	1.2	1.0	1.2	1.6	1.4	1.4
April	1.4	1.2	1.3	1.2	1.1	1.3	1.4	1.1	1.1
May	1.4	1.1	1.3	1.2	1.2	1.3	1.3	1.3	1.3
June	1.3	1.4	1.3	1.4	1.3	1.2	1.4	1.4	1.4
July	1.4	1.4	1.2	1.5	1.3	1.7	1.2	1.2	1.5
August	1.4	1.3	1.3	1.4	1.3	1.4	1.4	1.4	1.4
September	1.3	1.4	1.3	1.4	1.4	1.3	1.4	1.4	1.4
October	1.3	1.4	1.2	1.4	1.4	1.3	1.4	1.4	1.2
November	1.3	1.3	1.2	1.1	1.4	1.3	1.4	1.2	1.3
December	1.3	1.4	1.3	1.3	1.3	1.4	1.4	1.2	1.3

SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Federal and State agencies are involved in efforts to monitor continuously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained by radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Fresh milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, fresh milk is the single food item most often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of fresh milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (1-3). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of ex-

posure (3). Additional guidelines are provided by the FRC Protective Action Guides (4) and by the International Commission on Radiological Protection (5,6).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in

milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	January-December 1967	August 1968
1. Pasteurized Milk Network May 1968		

National Center for Radiological Health and
National Center for Urban and
Industrial Health, PHS

The Public Health Service's Pasteurized Milk Network (PMN) is designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, Washington, D. C., the Canal Zone, and Puerto Rico. The most recent description of the sampling and

analytical procedures employed by the PMN appeared in the January 1968 issue of *Radiological Health Data and Reports* (1). Reference should also be made to the February 1968 issue (2), in which several changes in the interpretation and reporting of data were introduced.

Table 1. Analytical errors associated with determinations of radionuclide concentrations in a milk sample

Nuclide	Concentration (pCi/liter)	Error * (pCi/liter)	Concentration (pCi/liter)	Error * (percent of concentration)
Strontium-90	<30	5	≥30	10
Strontium-90	<30	2	≥30	10
Iodine-131	<100	10	≥100	10
Cesium-137	<100	10	≥100	10
Barium-140	<100	10	≥100	10

* Two standard deviations.

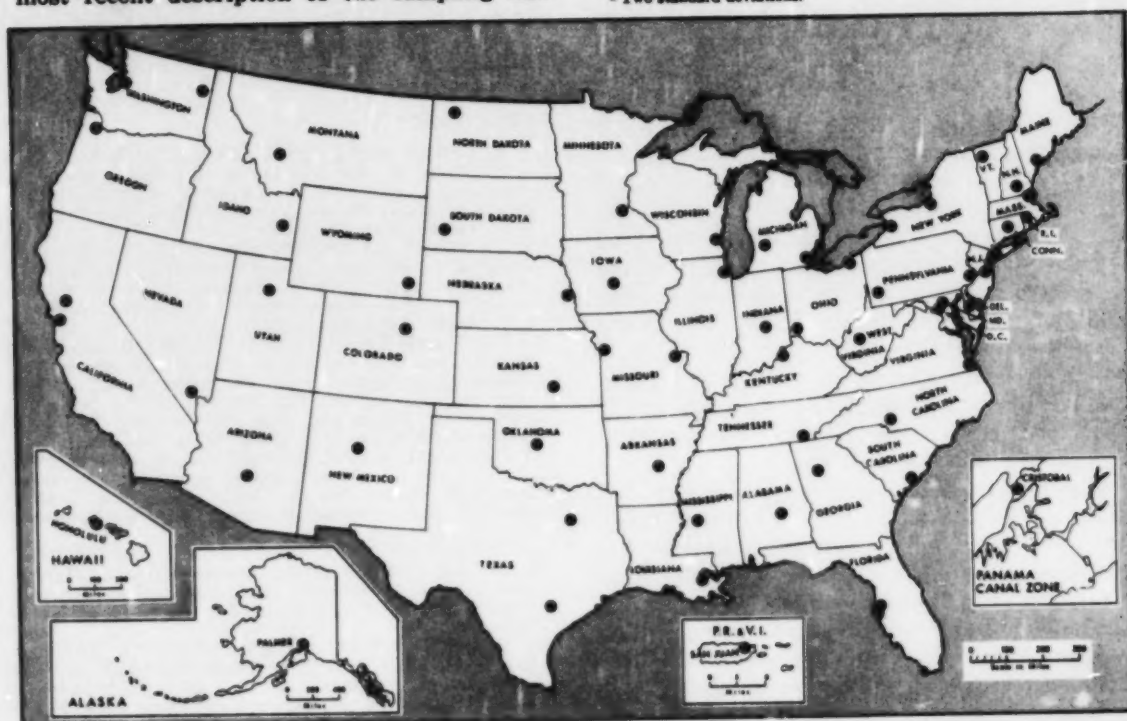


Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentrations of radionuclides in milk for May 1968 and the 12-month period, June 1967 through May 1968

Sample location		Radionuclide concentrations * (pCi/liter)									
		Strontium-90		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		June 1967- May 1968	May 1968	June 1967- May 1968	May 1968	June 1967- May 1968	May 1968	June 1967- May 1968	May 1968	June 1967- May 1968	May 1968
Ala:	Montgomery	0	0	0	0	0	0	12	16	0	0
Alaska:	Palmer	0	0	0	0	0	0	16	5	1	0
Ariz:	Phoenix	0	0	1	0	0	0	2	3	0	0
Ark:	Little Rock	1	11	21	23	0	0	19	34	0	0
Calif:	Sacramento	0	0	3	3	0	0	6	5	1	0
	San Francisco	1	6	3	0	0	0	4	8	1	0
C. E:	Cristobal	0	0	3	3	0	0	11	3	0	0
Colo:	Denver	1	0	5	3	0	0	7	8	0	0
Conn:	Harford	NA	NA	9	10	0	0	13	14	0	0
Del:	Wilmington	NA	NA	11	11	0	0	9	17	0	0
D. C:	Washington	0	0	10	10	0	0	5	6	0	0
Fla:	Tampa	0	0	8	8	0	0	70	60	0	0
Ga:	Atlanta	0	0	15	16	0	0	21	19	0	0
Hawaii:	Honolulu	0	0	3	4	1	0	5	5	0	0
Idaho:	Idaho Falls	1	0	6	7	0	0	8	6	0	0
Ill:	Chicago	0	0	9	10	0	0	10	9	0	0
Ind:	Indianapolis	NA	NA	7	7	0	0	7	7	0	0
Iowa:	Des Moines	0	0	7	8	0	0	7	0	0	0
Kans:	Wichita	1	0	9	12	0	0	4	10	0	0
Ky:	Louisville	0	0	12	13	0	0	5	7	0	0
La:	New Orleans	0	0	22	21	0	0	24	25	0	0
Maine:	Portland	NA	NA	10	NA	0	0	31	30	0	0
Md:	Baltimore	0	0	10	9	0	0	5	1	0	0
Mass:	Boston	0	0	12	13	0	0	26	21	0	0
Mich:	Detroit	NA	NA	8	8	0	0	13	13	0	0
	Grand Rapids	NA	NA	10	12	0	0	15	11	0	0
Minn:	Minneapolis	0	0	11	10	0	0	12	7	0	0
Miss:	Jackson	0	0	17	17	0	0	14	18	0	0
Mo:	Kansas City	1	6	9	10	0	0	4	9	1	0
	St. Louis	1	0	9	10	0	0	8	3	0	0
Mont:	Helena	1	0	5	0	0	0	7	5	1	0
Nebr:	Omaha	1	0	8	8	0	0	5	8	0	0
Nev:	Las Vegas	0	0	2	2	0	0	4	0	0	0
N. H:	Manchester	NA	NA	12	14	0	0	25	29	0	0
N. J:	Trenton	NA	NA	10	9	0	0	10	17	0	0
N. Mex:	Albuquerque	0	0	2	3	0	0	2	0	0	0
N. Y:	Buffalo	NA	NA	8	9	0	0	21	18	0	0
	New York City	NA	NA	7	14	0	0	13	18	0	0
	Syracuse	NA	NA	7	9	0	0	9	10	0	0
N. C:	Charlotte	0	0	16	14	1	0	13	11	0	0
N. Dak:	Minot	2	0	11	7	0	0	11	14	0	0
Ohio:	Cincinnati	NA	NA	9	12	0	0	6	9	0	0
	Cleveland	NA	NA	9	10	0	0	9	9	0	0
Okla:	Oklahoma City	0	0	10	12	0	0	4	7	0	0
Ore:	Portland	1	6	7	6	0	0	15	24	0	0
Pa:	Philadelphia	NA	NA	8	11	0	0	9	7	0	0
	Pittsburgh	NA	NA	12	11	0	0	14	15	0	0
P. R:	San Juan	0	0	5	4	0	0	11	2	0	0
R. I:	Providence	NA	NA	11	11	0	0	19	16	0	0
S. C:	Charleston	0	0	14	12	0	0	29	32	0	0
S. Dak:	Rapid City	1	0	11	9	0	0	10	10	0	0
Tenn:	Chattanooga	0	0	14	12	0	0	14	10	0	0
	Memphis	0	0	12	13	0	0	5	7	0	0
Tex:	Austin	0	0	4	3	0	0	4	2	0	0
	Dallas	0	NA	7	NA	0	0	5	5	0	0
Utah:	Salt Lake City	1	0	8	6	0	0	12	13	0	0
Va:	Norfolk	0	0	11	12	0	0	10	5	0	0
Vt:	Burlington	NA	NA	11	11	0	0	11	13	0	0
Wash:	Seattle	2	0	9	11	0	0	24	32	1	4
	Spokane	1	0	8	8	0	2	13	14	0	0
W. Va:	Charleston	0	0	11	15	0	0	4	0	0	0
Wisc:	Milwaukee	NA	NA	8	7	0	0	11	6	0	0
Wyo:	Laramie	0	NA	4	NA	0	0	6	12	0	0
Network monthly average		0	1	9	9	0	0	12	11	0	0

* See text for averaging procedure.
 † 12-month averages represent only 9 months data.
 NA no analysis.

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentra-

tions in milk. These errors were determined by comparing results of a large number of replicate analyses. Table 2 contains averages

for May 1968 and 12-month average for the period, June 1967 through May 1968. The 12-month average facilitates evaluations of population exposure with respect to the guidance provided by the Federal Radiation Council, which suggests average total daily intakes "averaged over periods of the order of a year," as an appropriate criterion (3). The average radionuclide concentrations are based on results obtained from samples collected weekly. Whenever weekly concentrations were less than or equal to the appropriate minimum detectable levels, zero was used for averaging purposes (2). At very low radionuclide concentrations this often results in averages lower than the

minimum detectable concentration for a single sample, but any positive value reflects at least one weekly sample which was above the minimum detectable level. The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium-89, 5; strontium-90, 2; iodine-131, cesium-137, and barium-140, 10.

The average strontium-90 concentrations in pasteurized milk from selected cities are presented in figure 2.

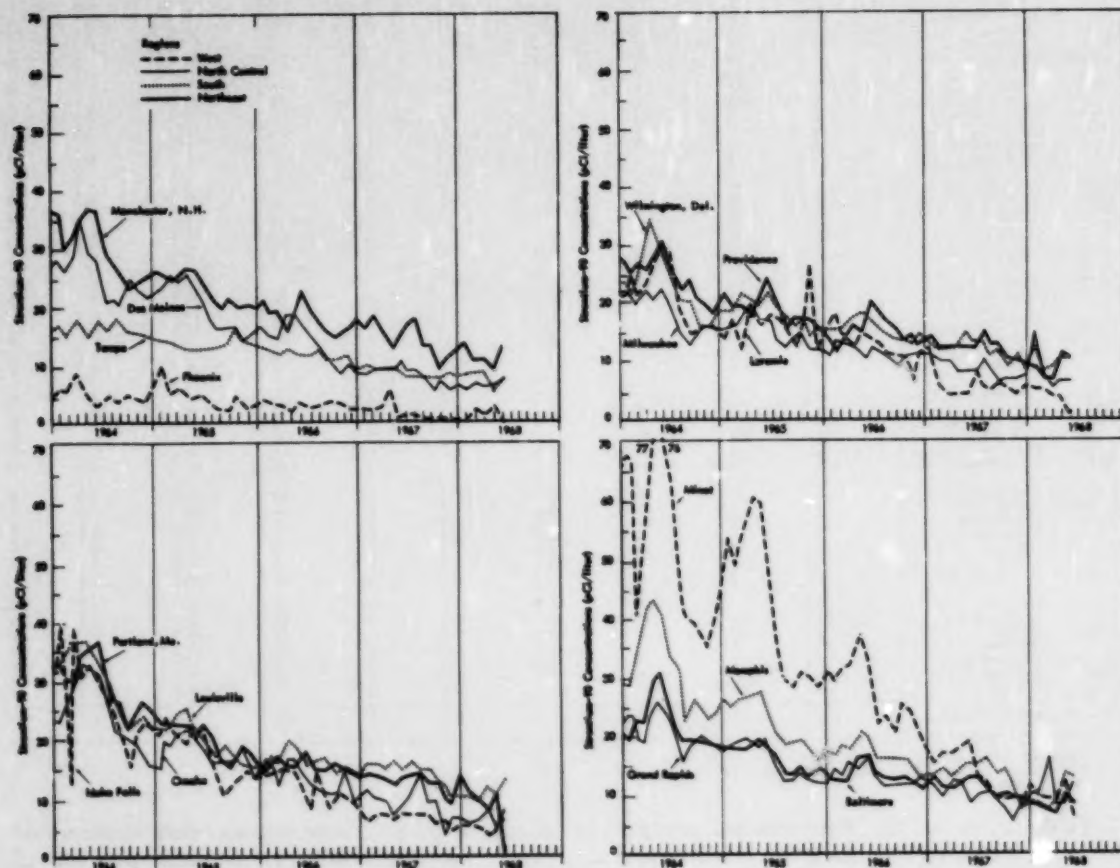


Figure 2. Strontium-90 concentrations in pasteurized milk, 1964-May 1968

2. Canadian Milk Network May 1968¹

*Radiation Protection Division
Department of National Health and Welfare*

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and potassium. The analytical procedures were out-

¹ Prepared from June 1968 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

lined in the April 1968 issue of *Radiological Health Data and Reports* (4).

The May 1968 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 3. Iodine-131 and strontium-89 concentrations were below minimum detectable levels.

Table 3. Stable elements and radionuclides in Canadian whole milk, May 1968

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary.....	1.11	1.5	8.5	14
Edmonton.....	1.15	1.4	7.0	17
Ft. William.....	1.11	1.5	16.8	18
Fredericton.....	1.06	1.6	16.3	19
Halifax.....	1.11	1.5	12.0	22
Montreal.....	1.09	1.5	9.6	22
Ottawa.....	1.13	1.4	9.2	17
Quebec.....	1.07	1.4	12.0	32
Regina.....	1.11	1.5	7.4	11
St. John's, Nfld.....	1.13	1.5	14.2	27
Saskatoon.....	1.11	1.4	9.2	19
Sault Ste. Marie.....	1.07	1.6	15.5	25
Toronto.....	1.13	1.5	5.4	17
Vancouver.....	1.15	1.4	16.8	48
Windsor.....	1.15	1.5	4.5	16
Winnipeg.....	1.07	1.8	7.8	21
Average.....	1.11	1.5	10.8	21



Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program May 1968

Pan American Health Organization and U.S. Public Health Service

The Pan American Health Organization (PAHO) in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (5).



Figure 4. Pan American Milk Sampling Program stations

Table 4 presents stable potassium, strontium-90 and cesium-137 monthly concentrations for May 1968.

Table 4. Stable element and radionuclide concentrations in Pan American milk,^a May 1968

Sampling station	Number of samples	Potassium (g/liter)	Strontium-90 ^b (pCi/liter)	Cesium-137 ^b (pCi/liter)
Chile: Santiago.....	4	1.63	0	0
Colombia: Bogota.....	1	1.56	0	0
Ecuador: Guayaquil....	2	1.55	0	0
Jamaica: Mandeville....	4	1.52	5	65
Venezuela: Caracas.....	4	1.51	0	0
Canal Zone: Cristobal ^c	4	1.52	3	3
Puerto Rico: San Juan....	4	1.56	4	2

^a All strontium-90 results were ≤ 5 pCi/liter; iodine-131 and barium-140 results were all ≤ 10 pCi/liter.

^b Strontium-90 single sample results ≤ 2 pCi/liter and cesium-137 single sample results ≤ 10 pCi/liter are reported as 0.

^c For comparison, the radionuclide concentrations in Pasteurized Milk Network samples collected at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

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State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing develop-

mental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows the States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs appearing in this issue are highlighted in the figure. Following is a summary of previously covered State programs, their reporting period, and the last issue in which they appeared.

State milk network

Colorado
Connecticut
Florida
Indiana
Iowa
Michigan
Minnesota
New York
Pennsylvania
Tennessee
Texas

Period reported

January-March 1968
January-March 1968
January-March 1968
January-March 1968
January-March 1968
January-March 1968
January-March 1968
January-March 1968
January-March 1968
January-March 1968
January-March 1968

Last presented

July 1968
August 1968
July 1968
August 1968
August 1968
August 1968
August 1968
August 1968
August 1968
July 1968
July 1968

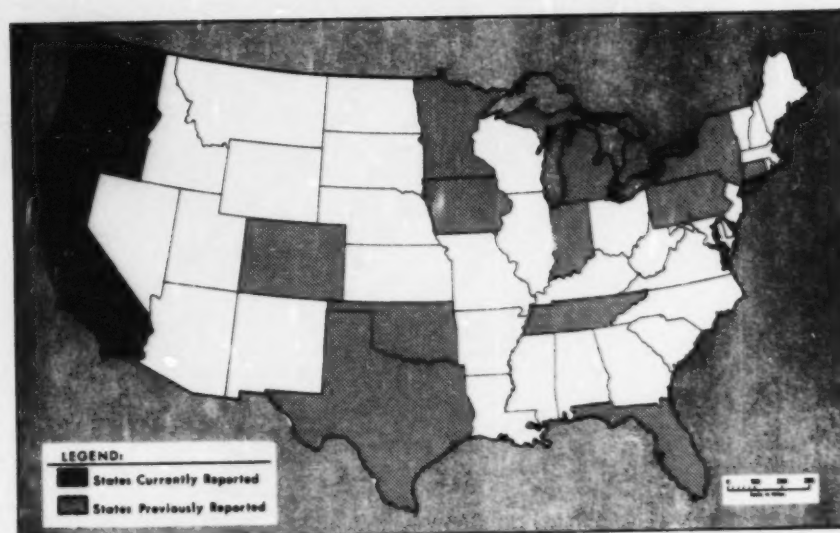


Figure 1. Reported State milk programs

**1. California Milk Network
January-March 1968**

*Division of Environmental Sanitation
State of California
Department of Public Health*

Surveillance of specific radionuclides in milk is one phase of the California Department of Health program on radiation control. This milk monitoring function is conducted by the Department's Bureau of Radiological Health at 10 major milksheds (figure 2).

In January 1960, the eight original sampling locations were chosen by the State Department of Agriculture so as to be representative of milk consumed by a high percentage of the State's population. The Del Norte and Mendocino milksheds were added to the program in March 1962 and since that time, weekly, bi-weekly or monthly sampling of pasteurized milk

has been conducted in 10 milkshed areas of the State. A description of the various California milksheds was presented earlier by Heslep and Cornish (1).

Strontium-89 and strontium-90 concentrations are determined radiochemically. Potassium-40, iodine-131, cesium-137, and barium-140 in whole fluid milk are determined by gamma-ray scintillation spectrometry. A detailed description of the analytical procedures was presented in an earlier report (2).

The monthly calcium, potassium and radionuclide concentrations in California pasteurized milk are given in table 1 for the period of January to March 1968. All iodine-131 concentrations remained below detectable levels of 10 pCi/liter during this period.

Network average strontium-90 and cesium-137 concentrations are presented graphically in figure 3.

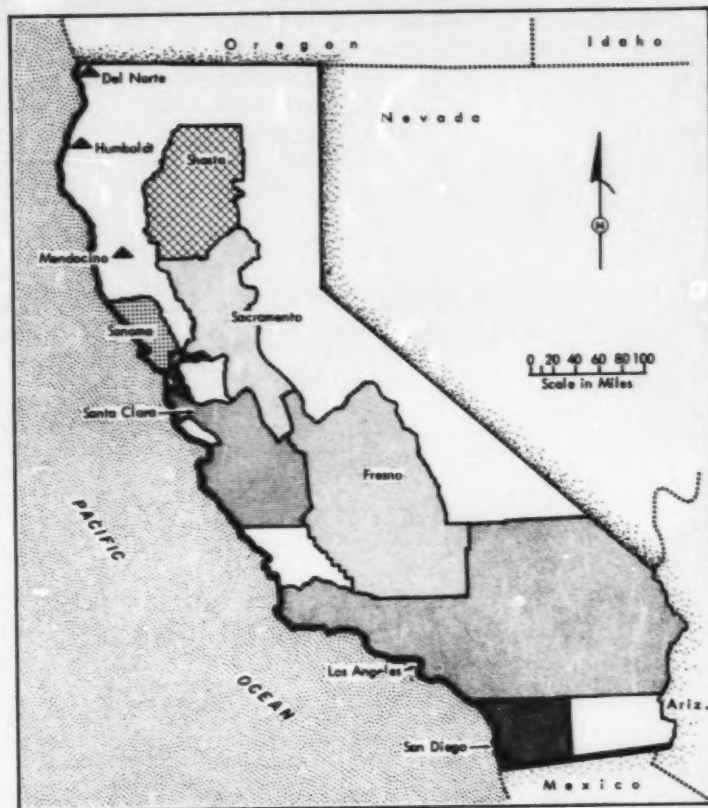


Figure 2. California milksheds

Table 1. Stable elements and radionuclides in California milk, January-March 1968

Sampling location	Calcium (g/liter)			Potassium (g/liter)			Strontium-90 (pCi/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)			Barium-140 (pCi/liter)		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Del Norte	1.27	NB	1.06	1.5	NB	1.4	18	NB	21	19	NB	20	24	NB	21	37	NB	21
Fresno	1.10	1.10	1.10	1.5	1.5	1.6	ND	ND	ND	ND	ND	ND	18	11	8	ND	18	13
Humboldt	1.16	1.15	1.18	1.5	1.5	1.4	10	11	ND	6	2	3	12	ND	6	34	ND	48
Los Angeles	1.11	1.12	1.01	1.6	1.5	1.6	ND	ND	ND	ND	ND	ND	ND	12	11	ND	ND	ND
Mendocino	1.13	1.33	1.14	1.6	1.5	1.7	3	ND	3	4	3	2	ND	ND	ND	ND	ND	ND
Sacramento	1.21	1.17	1.21	1.6	1.6	1.5	ND	ND	ND	2	2	2	ND	ND	ND	ND	ND	ND
San Diego	1.09	1.13	1.07	1.5	1.5	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Santa Clara	1.19	1.44	1.20	1.6	1.6	1.7	ND	ND	ND	ND	3	ND	ND	ND	ND	ND	ND	ND
Santa	1.13	0.94	1.04	1.4	1.5	1.4	ND	ND	ND	3	3	3	ND	ND	ND	ND	ND	ND
Sonoma	1.14	1.24	1.10	1.6	1.6	1.6	ND	3	ND	4	2	2	ND	ND	ND	ND	ND	ND

NB, no sample collected.

ND, nondetectable.

Minimum detectable levels: strontium-90—2.5 pCi/liter; strontium-90—1.5 pCi/liter; iodine-131—7 pCi/liter; cesium-137—7 pCi/liter; barium-140—7 pCi/liter.

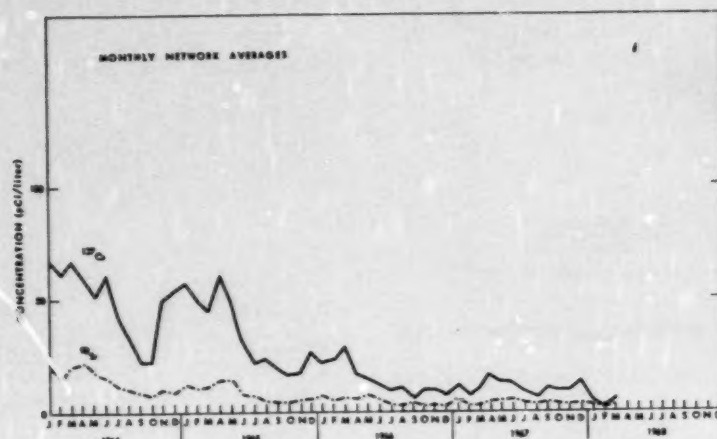


Figure 3. Radionuclide concentrations in California milk, 1964-March 1968

Recent coverage in Radiological Health Data and Reports:

Period
March 1968
July-September 1967

Issue
October-December 1967
June 1968

2. Oregon Milk Network January-March 1968

Division of Sanitation and Engineering
Oregon State Board of Health

The Oregon State Board of Health has monitored radionuclide concentrations in milk since March 1962. As part of this program routine milk samples are collected at seven major production areas (figure 4), which supply 90 percent of the milk distributed in Oregon. Currently, pasteurized milk samples are collected

monthly by the Oregon Department of Agriculture, except in the Portland area where weekly samples are collected by the city of Portland. The milk sampling frequency is accelerated to a weekly basis in areas where iodine-131 concentrations exceed 100 pCi/liter, or when cesium-137 concentrations exceed 500 pCi/liter. Strontium-90 analyses are performed on a bimonthly basis, but may be done monthly when significant increases are observed.

Strontium-90 concentrations are determined using an ion-exchange analytical procedure (3). Iodine-131, cesium-137, and barium-140

concentrations are determined by gamma-ray scintillation spectrometry (4).

Table 2 gives the strontium-90 and cesium-137 concentrations in pasteurized milk from January through March 1968. These data are presented graphically in figure 5. Iodine-131 and barium-140 concentrations remained below minimum detectable levels of 15 pCi/liter for all samples which were collected in January through March 1968.

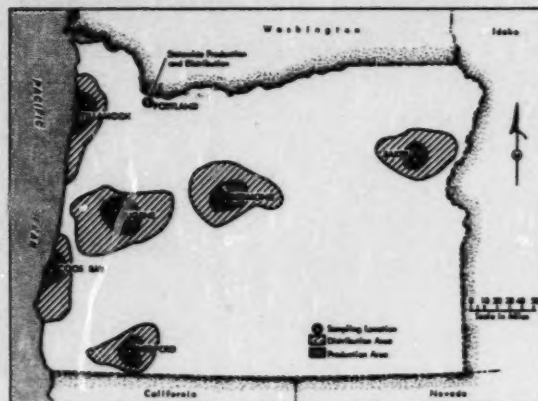


Figure 4. Oregon milk production and distribution areas

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July-September 1967	March 1968
October-December 1967	June 1968

3. Washington Milk Network January-March 1968

Office of Air Quality Control
State of Washington Department of Health

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 6 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. In addition to the eight milk sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint), as this area forms a part of the Spokane milkshed.

Table 2. Radionuclide concentrations in Oregon pasteurized milk, January-March 1968

Location	Sampling frequency	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
		Jan	Feb	Mar	Jan	Feb	Mar
Baker	M	7	NA	4	<15	24	<15
Coos Bay	M	7	NA	8	20	33	<15
Eugene	M	4	NA	4	21	18	<15
Medford	M	4	NA	3	19	36	<15
Portland composite	W	14	NA	4	18	19	16
Portland local	W	4	NA	9	20	19	16
Redmond	M	8	NA	4	<15	22	20
Tillamook	M	NA	NA	10	<15	24	<15

Key to symbols: M, sampled monthly.
W, sampled weekly.
NA, no analysis.

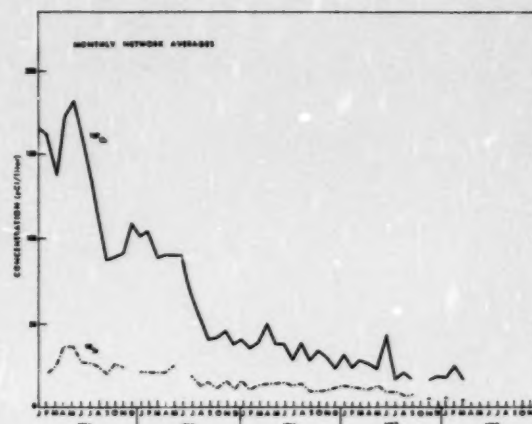


Figure 5. Radionuclide concentrations in Oregon milk network, 1964-March 1968

Details of the sampling procedures were presented in an earlier report (5).

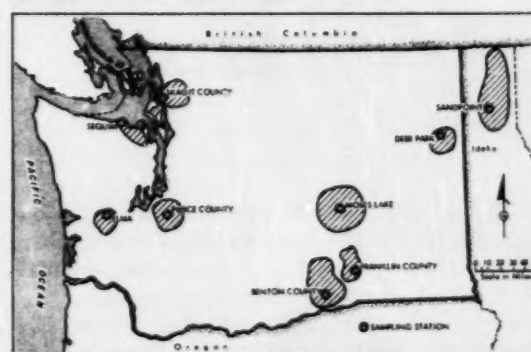


Figure 6. Washington milksheds and sampling locations

Table 3. Radionuclide concentrations in Washington raw milk January-March 1968

Sampling location	Potassium (g/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Benton County.....	1.5	NS	1.5	2	NS	1	<15	NS	<15
Deer Park.....	* 1.5	1.5	1.5	5	3	3	* <15	<15	<15
Elma.....	* 1.5	1.5	1.6	2	5	3	* <15	28	20
Franklin County.....	NS	1.7	NS	NS	1	NS	<15	NS	NS
Moses Lake.....	1.5	1.6	1.5	<1	1	3	<15	<15	<15
Pierce County.....	* 1.4	1.6	1.6	1	1	3	* <15	<15	<15
Sandpoint, Idaho.....	* 1.4	1.4	1.5	6	3	9	* <15	18	23
Sequim.....	* 1.4	NS	NS	1	NS	NS	* <15	NS	NS
Skagit County.....	1.4	1.6	1.4	3	2	3	<15	<15	<15

* Two samples represented in average.
NS, no sample.

Selected samples are radiochemically analyzed for strontium-90. Potassium-40, iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-ray scintillation spectrometry. Details of the analytical procedures were presented earlier (5).

Table 3 presents monthly radionuclide concentrations in Washington raw milk for January through March 1968. Samples collected during January through March 1968 contained less than 10 pCi/liter of iodine-131. Barium-140 results remained below 15 pCi/liter for all samples collected during this period. Monthly average strontium-90 and cesium-137 concentrations are presented graphically in figure 7 to display general trends.

During this reporting period, three samples were collected (one from Benton County and two from Franklin County) and analyzed for zinc-65. In all three cases, zinc-65 levels were less than 25 pCi/liter. Milk samples produced in areas using Columbia River water for irrigation have periodically been found to contain this radionuclide.

Recent coverage in Radiological Health Data and Reports:

Period	Issue
July-September 1967	March 1968
October-December 1967	June 1968



Figure 7. Radionuclide concentrations in Washington milk, 1964-March 1968

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- (2) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH. California milk network, 1960-June 1962. Radiol Health Data 4:90-92 (February 1963).
- (3) PORTER, C. R., M. W. CARTER, B. KAHN, and E. W. PEPPER. Rapid Field Method for the Collection of Radionuclides from Milk. Proceedings of the First International Congress of the International Radiation Protection Association held in Rome, Italy, September 5-10, 1966 (in press).
- (4) OREGON STATE BOARD OF HEALTH, DIVISION OF SANITATION AND ENGINEERING. Oregon milk network, April-June 1965. Radiol Health Data 6:683-684 (December 1965).
- (5) STATE OF WASHINGTON DEPARTMENT OF HEALTH, AIR AND RADIATION CONTROL SECTION. Washington milk network, January-June 1965. Radiol Health Data 6:619-621 (November 1965).

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and re-

ported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows.

<u>Program</u>	<u>Period reported</u>	<u>Last presented</u>
California Diet Study	July-October 1967	May 1968
Connecticut Standard Diet	July-December 1967	May 1968
Institutional Total Diet, <i>PHS</i>	October-December and annual summary 1967	July 1968
Tri-City Diet, <i>HASL</i>	April-December 1967	June 1968

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SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (1). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (2-4), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits

may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence¹ of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

¹ Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Last presented
California	January-June 1967	June 1968
Colorado River Basin	1965-1966	May 1968
Coast Guard	January-December 1966	November 1967
Minnesota	January-June 1967	January 1968
New York	January-May 1967	January 1968
Radiostromium in Tap Water, HASL	July-December 1967	June 1968
Florida	1965-1966	July 1968
Washington	July 1966-June 1967	August 1968

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- (1) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).
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Gross Radioactivity in Surface Waters of the United States, March 1968

*Division of Pollution Surveillance
Federal Water Pollution Control
Administration
Department of the Interior*

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity

in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (1-6). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity concentration is 15 pCi/liter or greater or when the beta radioactivity concentration is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health

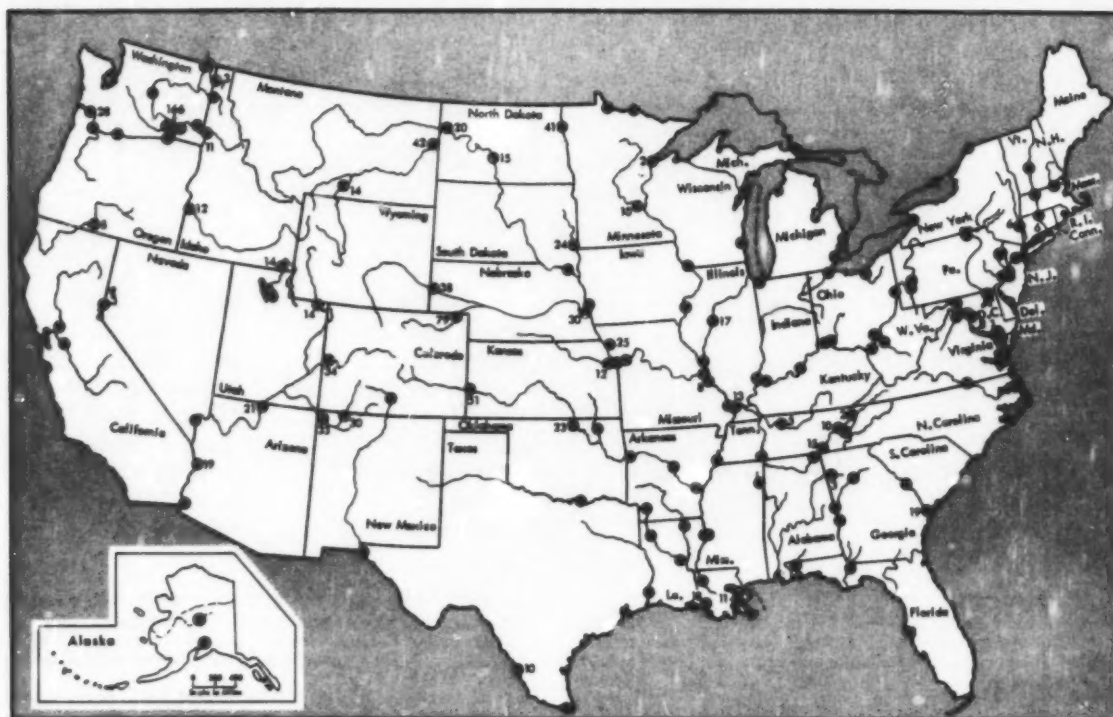


Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, March 1968

Table 1. Radioactivity in raw surface waters, March 1968

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)			Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:							Mississippi River:						
Cedar Hill, N. Mex.	7	2	9	23	7	30	St. Paul, Minn.	0	0	0	1	9	10
Arkansas River:							E. St. Louis, Ill.	0	1	1	1	7	8
Coolidge, Kans.	1	37	38	11	40	51	New Orleans, La.	1	1	2	3	8	11
Ponca City, Okla.	0	4	4	3	20	23	Missouri River:						
Atchafalaya River:							Williston, N. Dak.	3	1	4	10	10	20
Morgan City, La.	3	1	4	12	6	18	Bismarck, N. Dak.	0	2	2	1	14	15
Boz River:	0	2	2	0	14	14	St. Joseph, Mo.	2	4	6	8	20	25
Fresno, Idaho	0	2	2	0	14	14	North Platte River:						
Big Horn River:							Henry, Nebr.	<1	30	30	3	35	38
Hardin, Mont.	0	5	5	1	18	14	Ohio River:						
Big Sioux River:							Cairo, Ill.	3	0	3	8	5	13
Sioux Falls, S. Dak.	<1	3	3	4	20	24	Pend Oreille River:						
Clearwater River:	0	<1	<1	3	8	11	Albion Falls Dam, Idaho	0	0	0	<1	3	3
Lewiston, Idaho	0	<1	<1	0	2	2	Platte River:						
Chinle River:	0	0	0	0	2	2	Plattsmouth, Nebr.	4	5	9	12	18	30
Clinton, Tenn.	0	<1	<1	<1	10	10	Potomac River:						
Kingston, Tenn.	0	<1	<1	<1	10	10	Washington, D. C.	1	0	1	5	3	8
Colorado River:							Red River, North:						
Loma, Colo.	3	9	12	12	22	34	Grand Forks, N. Dak.	0	<1	<1	2	20	41
Pago, Ariz.	0	5	5	<1	21	21	Rio Grande:						
Parker Dam, Calif.	0	6	6	1	18	19	Laredo, Tex.	0	2	2	2	8	10
Ariz.	0	6	6	1	18	19	San Juan River:						
Columbia River:							Shiprock, N. Mex.	8	3	11	23	10	33
Pasco, Wash.	0	1	1	30	196	166	Savannah River:						
Catawba, Ore.	0	0	0	9	10	28	Port Wentworth, Ga.	<1	0	<1	3	18	19
Connecticut River:							Snake River:						
Enfield Dam, Conn.	0	0	0	2	4	6	Payette, Idaho	0	4	4	1	11	12
Coosa River:							South Platte River:						
Rome, Ga.	1	0	1	1	2	3	Julesburg, Colo.	5	35	40	19	60	79
Cumberland River:							Tennessee River:						
Chatham Lock, Tenn.	0	0	0	1	4	5	Chattanooga, Tenn.	1	0	1	10	5	15
Great Lakes:							Yellowstone River:						
Duluth, Minn.	0	0	0	0	2	2	Sidney, Mont.	7	3	10	28	14	42
Green River:							Maximum	8	37	40	30	136	166
Dutch John, Utah	0	2	2	<1	14	14	Minimum	0	0	0	0	2	2
Hudson River:													
Poughkeepsie, N. Y.	0	0	0	1	5	6							
Illinois River:													
Peoria, Ill.	3	1	4	10	7	17							
Kansas River:													
DeSoto, Kans.	0	2	2	0	12	12							
Klamath River:													
Keno, Ore.	0	<1	<1	1	7	8							

* Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (7). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During February and March the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for dissolved solids:

Arkansas River; Coolidge, Kans.

North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the

Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network
HASL 80th Meridian Network

Period
Calendar year 1965

Issue
January 1967

1. Radiation Alert Network May 1968

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection when most of the radon daughter products have decayed and at 29 hours after collection when most of the thoron

daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate National Center for Radiological Health officials by mail or telephone, depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (1). A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during May 1968. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.



Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and deposition, May 1968

Station location	Number of samples		Air surveillance gross beta radioactivity ($\mu\text{Ci}/\text{m}^3$)			Last profile in RHD&R	Precipitation			
							Field estimation of deposition ^a			
	Air	Pptn	Maximum	Minimum	Average ^b		Total depth (mm)	Number of samples	Depth (mm)	Total deposition ($\mu\text{Ci}/\text{m}^2$)
Ala: Montgomery	22	2	7.31	0.41	2.14	Sept 68	40	2	40	15
Alaska: Adak	30		1.07	.00	.03	Apr 68	(*)			
Anchorage	17	6	.48	.00	.07	Dec 67	32	4	18	0
Attu Island	(*)					May 68	(*)			
Fairbanks	15	2	1.94	.00	.34	Jan 68	11	2	11	0
Juneau	21	9	.34	.00	.01	Feb 68	53	9	53	0
Kodiak	19		1.62	.00	.31	Mar 68	(*)			
Noise	(*)					July 68	(*)			
Pt. Barrow	31		1.25	.00	1.14	June 68	(*)			
St. Paul Island	31		.45	.43	.43	Aug 68	(*)			
Aris: Phoenix	21	2	8.47	1.65	3.67	Feb 68	(*)			
Ark: Little Rock	9	2	1.49	.23	.65	Dec 67	98	0	0	(*)
Calif: Berkeley	22	1	.39	.00	.21	Mar 68	4	1	4	0
Los Angeles	23		1.67	.22	.80	July 68	(*)			
C. S.: Ancon	17	2	3.23	1.50	2.43	Mar 68	(*)			
Colo: Denver	22	2	6.81	.71	2.66	Mar 68	11	(*)	(*)	(*)
Conn: Hartford	22	8	.57	.34	.28	Jan 68	111	8	111	0
Del: Dover	22		2.23	.18	.65	Sept 68	(*)			
D. C.: Washington	30	10	1.64	.34	.77	June 68	102	10	102	8
Fla: Jacksonville	22	6	1.10	.29	.57	Dec 67	132	0	0	(*)
Miami	21	9	1.65	.16	.41	Jan 68	227	9	227	0
Ga: Atlanta	22	1	1.27	.41	.99	Aug 68	10	0	0	(*)
Gram: Agassiz	31		.67	.00	.22	Sept 68	(*)			
Hawaii: Honolulu	30		.89	.03	.48	May 68	(*)			
Idaho: Boise	20	2	5.42	.90	2.11	May 68	9	3	9	0
Ill: Springfield	17	5	8.25	1.04	2.76	June 68	30	0	0	(*)
Ind: Indianapolis	20	8	3.52	.64	1.57	Aug 68	157	8	157	212
Iowa: Iowa City	21	3	5.48	.51	2.34	Mar 68	15	0	0	(*)
Kans: Topeka	21	7	4.78	.48	1.59	Dec 68	53	7	53	0
Ky: Frankfort	13	5	.87	.42	.67	June 68	39	5	39	32
La: New Orleans	22	3	1.02	.34	.86	June 68	47	(*)	(*)	(*)
Maine: Augusta	20	4	3.01	.59	.59	July 68	63	4	63	0
Md: Baltimore	19	3	4.07	.34	1.25	Jan 68	32	5	32	7
Rockville	(*)					May 68	(*)			
Mass: Lawrence	22	5	1.21	.00	.53	Sept 68	73	1	73	0
Winchester	21	7	2.58	.00	.46	Apr 68	72	7	72	0
Mich: Lansing	22	13	3.28	.95	1.95	May 68	106	13	106	64
Minn: Minneapolis	21	9	.42	.20	.23	Sept 68	108	9	108	94
Miss: Jackson	18	3	2.16	.30	.88	July 68	126	3	126	134
Mo: Jefferson City	23	8	4.37	.37	1.27	Aug 68	129	8	129	0
Mont: Helena	22	5	3.12	.34	1.34	Apr 68	39	5	39	38
Neb: Lincoln	15	2	4.50	.59	2.53	Aug 68	14	2	14	0
Nev: Las Vegas	20		2.20	.18	1.16	Jan 68	(*)			
N. H.: Concord	21	9	2.09	.00	.96	June 68	158	9	158	190
N. J.: Trenton	21		.80	.19	.74	July 68	9	1	9	9
N. Mex: Santa Fe	19	1	2.36	.22	.77	Apr 68	65	8	65	64
N. Y.: Albany	22	8	2.46	.17	.54	Aug 68	(*)			
Buffalo	23		1.47	.21	.58	Mar 68	(*)			
New York City	20		.94	.28	.38	Apr 68	(*)			
N. C.: Gastonia	17	2	10.87	.55	3.75	Mar 68	26	(*)	(*)	(*)
N. Dak: Bismarck	23	6	4.78	.76	1.79	June 68	68	0	0	(*)
Ohio: Cincinnati	22		3.89	.51	1.64	Sept 68	(*)			
Columbus	18	10	1.98	.06	.89	July 68	209	8	209	0
Palmerville	23	12	2.93	.06	.87	Jan 68	86	12	86	67
Oklahoma City	15	5	4.54	.21	1.20	May 68	129	5	129	276
Ore: Pocatello	21	7	2.12	.16	.54	Jan 68	106	7	106	0
Portland	21	10	1.04	.00	.31	Aug 68	58	10	58	0
Pa: Harrisburg	17		3.05	.38	1.12	Aug 68	(*)			
P. R.: San Juan	(*)					July 68	(*)			
R. I.: Providence	17		.71	.00	.30	May 68	(*)			
S. C.: Columbia	19	6	.86	.00	.46	Apr 68	36	0	0	(*)
S. Dak: Pierre	13		7.99	1.02	2.35	Feb 68	(*)			
Tenn: Nashville	22	8	2.10	.27	.75	May 68	221	8	221	0
Tex: Austin	20	5	9.48	.34	2.53	Sept 68	90	(*)	(*)	(*)
El Paso	21		4.48	1.33	2.32	June 68	(*)			
Utah: Salt Lake City	21	6	1.92	.22	1.01	July 68	21	0	0	(*)
Va: Barro	22	7	2.68	.23	1.05	Dec 67	73	7	73	0
Richmond	15	2	.78	.39	.55	Dec 67	17	0	0	(*)
Wash: Seattle	25	5	.72	.00	.06	Dec 67	20	(*)	(*)	(*)
Spokane	22	1	3.46	.74	1.58	Sept 68	1	0	0	(*)
W. Va: Charleston	21	7	16.91	.25	2.94	Apr 68	78	7	78	82
Wis: Madison	22	7	1.26	.20	.69	Dec 67	55	7	55	85
Wyo: Cheyenne	23	8	6.38	.34	2.32	Jan 68	98	8	98	73
Network summary	1,426	285	16.91	0.00	1.13		71	6	81	60

^a The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.^b No report received. (Air samples received without field estimate data are not considered by the data program).^c No precipitation sample collected.^d Indicates that the station is part of the plutonium in precipitation network. No gross beta measurements are done.^e Samples were collected but no field estimates were reported.^f The data in these columns apply only to samples for which field estimates were made.

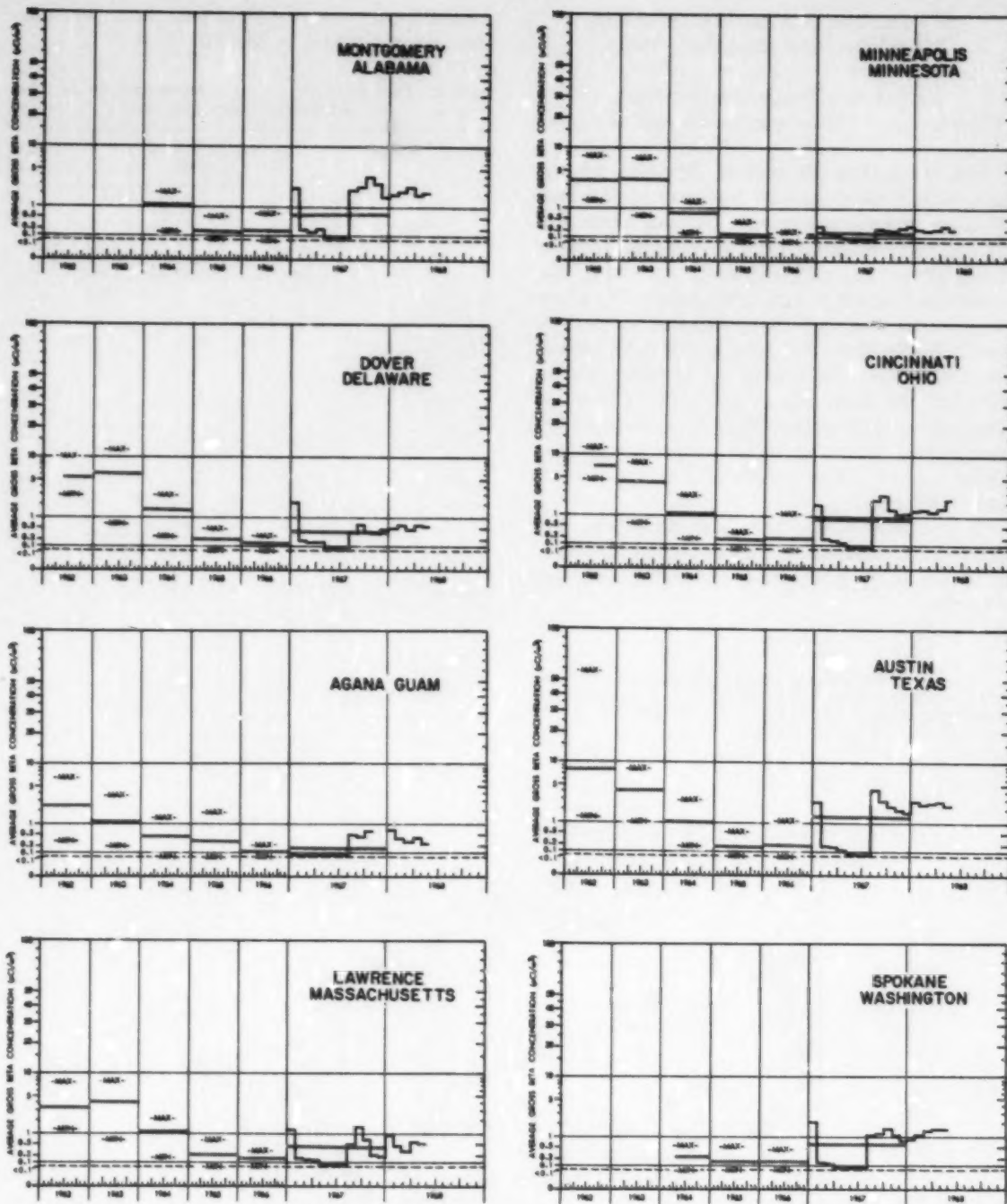


Figure 2. Monthly and yearly profiles of beta radioactivity in air—
Radiation Alert Network, 1962-May 1968

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2. Canadian Air and Precipitation Monitoring Program, May 1968¹

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (2-6).

A summary of the sampling procedures and methods of analysis was presented in the April 1968 issue of *Radiological Health Data and Reports*.

¹ Prepared from information and data in the June 1968 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for May 1968 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, May 1968

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m ³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (mCi/m ²)
Calgary	31	0.7	0.0	0.3	180	9.3
Coral Harbour	31	.3	.0	.1	195	4.9
Edmonton	31	.5	.0	.2	156	4.6
Ft. Churchill	30	.4	.1	.2	237	2.7
Ft. William	31	.4	.1	.2	117	10.7
Fredericton	31	.3	.0	.2	82	3.5
Goose Bay	31	.3	.0	.1	61	2.8
Halifax	29	.4	.0	.2	74	6.7
Inuvik	31	.3	.0	.1	53	1.1
Montreal	31	.4	.0	.2	97	4.9
Moosonee	31	.5	.0	.2	35	0.6
Ottawa	31	.4	.0	.2	130	5.7
Quebec	31	.3	.0	.1	72	5.2
Regina	31	.5	.0	.2	157	4.7
Resolute	26	.3	.0	.1	52	0.9
St. John's, Nfld.	30	.3	.0	.1	32	4.7
Saskatoon	31	.4	.0	.2	111	6.3
Sault Ste. Marie	27	.6	.0	.2	123	7.6
Toronto	30	.4	.0	.2	111	10.6
Vancouver	31	.5	.0	.2	68	4.3
Whitehorse	31	.3	.0	.1	163	5.2
Windsor	31	.4	.0	.2	75	10.4
Winnipeg	30	.3	.0	.2	53	8.2
Yellowknife	31	.3	.0	.1	177	2.1
Network summary	30	0.4	0.0	0.2	110	5.3



Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program May 1968

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the

Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high-volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (7).

The maximum, minimum, and average beta radioactivity in surface air during May 1968 are presented in table 3.

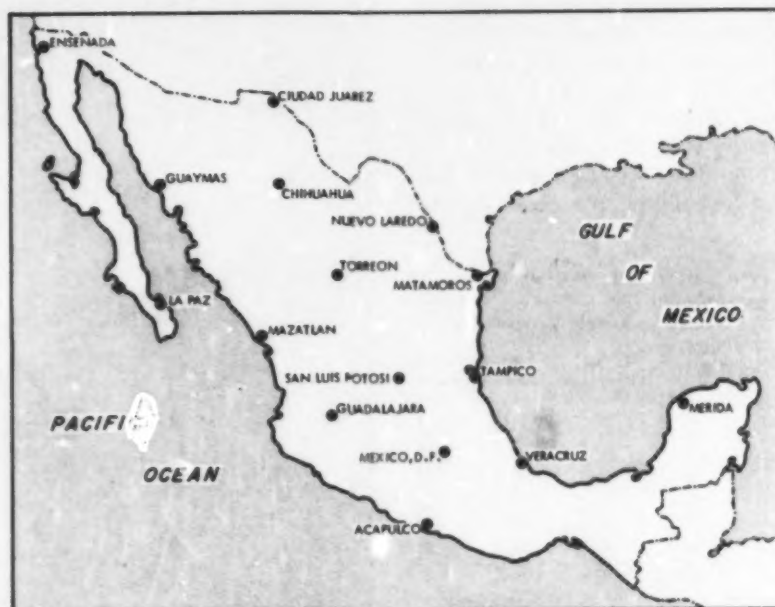


Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta radioactivity of airborne particulates, May 1968

Station	Number of samples	Gross beta radioactivity (pCi/m ³)		
		Maximum	Minimum	Average *
Acapulco.....	NS	NS	NS	NS
Chihuahua.....	2	0.4	0.3	—
Ciudad Juarez.....	5	.5	.2	0.4
Ensenada.....	NS	NS	NS	NS
Guadalajara.....	NS	NS	NS	NS
Guaymas.....	NS	NS	NS	NS
La Paz.....	15	.5	.1	.4
Matamoros.....	NS	NS	NS	NS
Morelia.....	7	1.2	0.2	.5
Mérida.....	15	.4	.1	.2
México, D. F.....	1	.1	.1	—
Nuevo Laredo.....	3	.1	.1	.1
San Luis Potosí.....	NS	NS	NS	NS
Tampico.....	12	.5	<.1	.1
Torreón.....	11	.3	.1	.2
Veracruz.....	2	.1	.1	—

NS, station temporarily shut down, no sample.

4. Pan American Air Sampling Program May 1968

Pan American Health Organization and U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling locations are shown in figure 5. Analytical techniques were described in

the January 1968 *Radiological Health Data and Reports*. The May 1968 air monitoring results from the participating countries are given in table 4.

Table 4. Summary of gross beta radioactivity in Pan American surface air, May 1968

Station location	Number of samples	Gross beta radioactivity (pCi/m ³)		
		Maximum	Minimum	Average *
Argentina: Buenos Aires..	22	0.07	0.01	0.02
Bolivia: La Paz.....	20	.04	.01	.02
Chile: Santiago.....	29	.06	.01	.03
Colombia: Bogotá.....	21	.03	.00	.01
Ecuador: Guayaquil.....	20	.07	.02	.03
Jamaica: Kingston.....	21	.33	.06	.12
Peru: Lima.....	13	.03	.01	.02
Venezuela: Caracas.....	17	.23	.03	.16
West Indies: Trinidad.....	21	.16	.03	.06
Pan American summary..	184	0.33	0.00	0.05

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.



Figure 5. Pan American Air Sampling Program stations

5. Fallout in the United States and Other Areas¹ July-December 1967

Health and Safety Laboratory
Atomic Energy Commission

Monthly fallout deposition rates for strontium-90 are determined by the Health and Safety Laboratory (HASL) for 49 sites in the United States and 107 locations in other countries. HASL data from all of the active United States stations and other selected points in the Western Hemisphere (figure 6) covering the period from July through December 1967, are summarized in tables 5 and 6. All the stations of the 80th Meridian Network are represented.

Methods of collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of 1 month in a stainless steel pot with an exposed area of 0.076 m². At the end of the col-

lection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with an exposed area of 0.072 m², attached to an ion exchange column. After a 1-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95 percent confidence level there was no significant difference in the strontium-90 measurements obtained from samples collected by the two methods (1).

Laboratories at Westwood, N. J., New York City, N. Y., and Seattle, Wash., have analyzed monthly precipitation samples for other radionuclides. The amount of precipitation at each station and the monthly deposition rates for

¹ The data in this article were taken from "Fallout Program Quarterly Summary Report," HASL-197:A-4 to A-180; HASL-193:II-9 to II-25 (July 1968; April 1968).

Table 5. Strontium-90 fallout in the United States, HASL, July-December 1967

Sampling location	Type of collection	Deposition (mCi/m ²)					
		July	Aug	Sept	Oct	Nov	Dec
Ala: Birmingham.....	pot	0.08	0.06	0.03	0.04	0.05	0.04
Alaska: Anchorage.....	column	.08	.06	.04	.01	.02	.04
Barrow.....	column	.04	.01	T	T	.15	T
Cold Bay.....	column	.04	.06	.03	.05	.06	.06
Fairbanks.....	column	.08	.08	.01	T	.01	.01
Juneau.....	column	.08	.08	.05	T	.04	.03
Nome.....	column	.09	.04	.01	.01	T	.02
Calif: W. Los Angeles.....	pot	.01	.01	.04	T	.08	T
San Francisco.....	column	.01	.01	.01	T	.01	T
Colo: Denver.....	column	.08	.04	NS	.05	T	T
Fla: Coral Gables.....	pot	.08	.05	.07	NS	NS	NS
Miami.....	column	.03	.06	.03	.05	.04	.01
Hawaii: Hilo.....	column	.10	.06	.06	.05	.07	.08
Honolulu.....	pot	.09	.16	.15	.04	.21	.08
Lihue.....	column	.04	.02	.01	.02	NS	.05
Maine: Lee.....	column	.03	.01	.01	T	T	T
Ill: Argonne.....	pot	.07	.08	.04	.05	.03	.05
La: New Orleans.....	column	.05	.04	.02	.01	.01	.02
Miss: International Falls.....	column	.18	.07	.03	.02	.01	.03
Mo: Columbia.....	column	.03	.03	.03	.05	.01	.04
Mont: Helena.....	column	.08	.04	.02	.01	.02	.02
N. J: Westwood.....	pot	.10	NS	NS	NS	NS	NS
N. Y: New York City.....	pot	.18	.12	.04	.04	.05	.09
N. Dak: Williston.....	column	.04	.05	.04	.03	T	.04
Ohio: Wooster.....	pot	.07	.07	.06	.03	.02	.04
Okla: Tulsa.....	pot	.11	.06	.17	.04	.02	.01
Ore: Medford.....	column	.01	.01	.02	.02	.02	.03
S. C: Columbia.....	column	.06	.07	.01	T	.03	.02
S. Dak: Vermillion.....	pot	.03	.16	.07	.03	T	.01
Tex: Dallas.....	column	.06	.02	.05	.03	.02	.01
El Paso.....	column	.03	.02	.01	.02	T	.02
Houston.....	column	.08	NS	.04	.01	NS	NS
Utah: Salt Lake City.....	pot	.06	.02	.04	.02	.03	.10
Va: Sterling.....	column	.11	.08	.01	.01	.02	.04
Wash: Seattle.....	pot	NS	NS	NS	NS	NS	NS
Forks.....	pot	.03	T	.03	.08	.06	.06
Wisc: Green Bay.....	column	.03	.02	.03	T	.06	.01
		.04	.06	.03	.04	.02	.02

NS, no sample reported.
T, trace or zero.

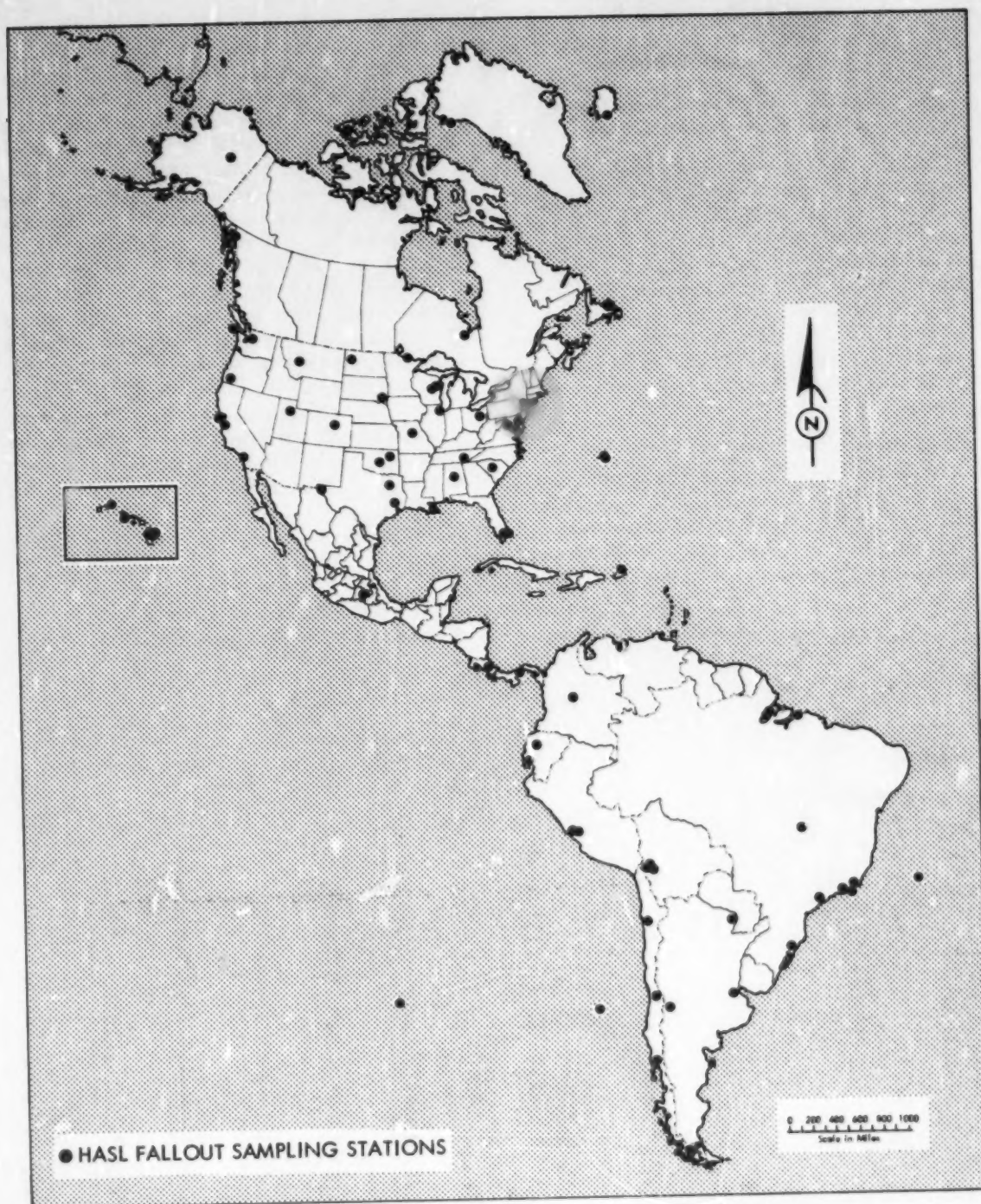


Figure 6. HASL fallout sampling stations in the Western Hemisphere

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Table 6. Strontium-90 fallout in North and South America, HASL, July-December 1967

Sampling location		Type of collection	Deposition (nCi/m ²)					
			July	Aug	Sept	Oct	Nov	Dec
Argentina:	Buenos Aires	column	0.06	0.08	0.04	0.08	0.06	0.03
	Formosa	column	.01	.02	T	.05	.02	.03
	Malargue	column	.07	T	NS	.02	.02	.02
Bahamas:	Bimini	column	.09	.07	.04	.04	.02	.02
Bermuda:	Kindley AFB	column	.08	.03	.04	.05	.02	.03
Bolivia:	Chacaltaya	column	.01	.01	.03	T	.02	.02
	La Paz (city)	column	.03	.02	.03	.02	.02	.02
	La Paz (Ovejuyo)	column	.04	.02	.03	.02	.02	.02
Brasil:	Belem	column	.03	.03	.01	NS	NS	NS
	Brasilia	pot	NS	NS	NS	NS	NS	NS
	Itai Sai Paulo	pot	NS	NS	NS	NS	NS	NS
	Nova Friburgo	pot	.02	T	.01	.03	NS	NS
	Rio de Janeiro	column	.01	.05	.08	.03	.04	NS
	San Jose Dos Campos	pot	NS	NS	NS	NS	NS	NS
	San Leopoldo	pot	.02	.04	.08	.10	.03	NS
	Trindade Island	column	NS	NS	.09	NS	NS	NS
Canada:	Moose	column	.16	.09	.03	.02	.02	.02
Canal Zone:	Antofagasta	column	.06	.04	NS	.02	.02	.03
Chile:	Isla Robinson Crusoe *	column	NS	NS	NS	NS	NS	NS
	Easter Island	column	.01	.02	.03	.02	.05	.04
	Puerto Montt	column	.11	.13	.07	.04	T	.05
	Punta Arenas	column	.03	.02	NS	T	.02	.04
	Santiago	pot	.02	.02	.04	.02	T	NS
	Bogota	column	.04	.02	.04	.01	T	.02
Colombia:	Bogota	pot	.01	T	T	T	T	T
Costa Rica:	Turrialba	column	NS	.03	.04	T	.02	T
Equador:	Guayaquil	column	NS	NS	NS	NS	NS	NS
	Quito	column	.02	.01	T	NS	.01	NS
Greenland:	Thule	column	.08	.02	T	T	T	T
Iceland:	Keflavik	column	.01	.05	.06	.02	.02	.06
Mexico:	Mexico City	column	.04	.04	.01	T	T	.01
	Lima	column	.01	.02	.01	T	T	T
Peru:	Lima	column	.01	.01	T	T	T	NS
Puerto Rico:	San Juan	column	.06	.04	.02	.01	.03	.03
Venezuela:	Caracas (site 1)	column	NS	.02	.02	.01	.01	.02
	Caracas (site 2)	column	.02	.01	.02	.01	T	T

* I. Alejandro Selkirk

b indicates proportioned from originally consolidated data.

NS, no sample reported

T, trace or zero

iron-55, strontium-90, plutonium-238, and plutonium-239-240, at each station are presented in table 7.

Table 7. Radiochemical analyses of precipitation samples at 3 U.S. sites, HASL, July-December 1967

	July	Aug	Sept	Oct	Nov	Dec
Precipitation (cm)						
N. J.: Westwood	14.32	NS	NS	NS	NS	NS
N. Y.: New York City	17.75	15.09	4.67	8.81	6.58	15.44
Wash.: Seattle	0.13	T	3.07	13.77	5.10	13.54
Iron-55 (nCi/m ²)						
N. J.: Westwood	1.08	NS	NS	NS	NS	NS
Wash.: Seattle	2.32	NS	NS	NS	NS	NS
Strontium-90 (nCi/m ²)						
N. J.: Westwood	0.10	NS	NS	NS	NS	NS
N. Y.: New York City	.18	0.12	0.04	0.04	0.05	0.09
Wash.: Seattle	NS	NS	NS	NS	NS	NS
Plutonium-238 (nCi/m ²)						
N. Y.: New York City	.00245	NS	NS	NS	NS	NS
Wash.: Seattle	NS	NS	NS	NS	NS	NS
Plutonium-239-240 (nCi/m ²)						
N. Y.: New York City	.00257	NS	NS	NS	NS	NS
Wash.: Seattle	NS	NS	NS	NS	NS	NS

NS, no sample reported.

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained

from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Strontium-90 in Human Bone, April-June 1967¹

*National Center for Radiological Health
Public Health Service*

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older age groups have shown their bone strontium-90 content to be low and age-independent (1). Consequently, the target population includes children and young adults up to 25 years of age.

¹ Period during which death or surgical procedure occurred.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age.

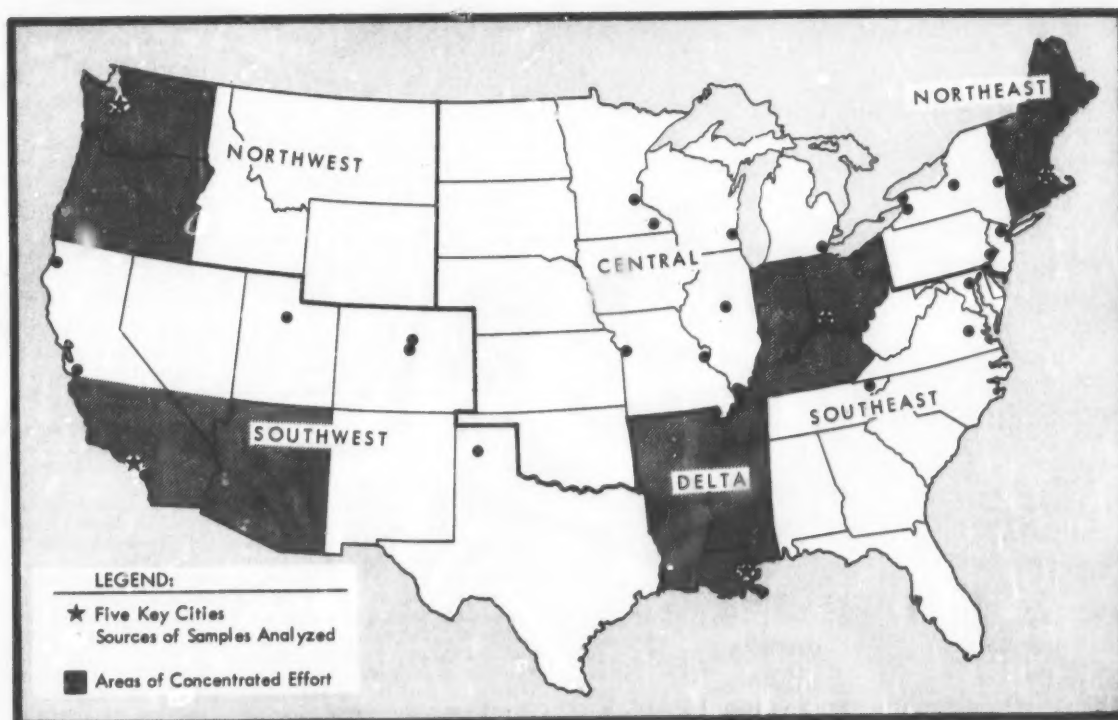


Figure 1. Geographical regions for human bone sampling

Table 1. Strontium-90 in human bone, April-June 1968

Bone region and State of residence	Bone type ^a	Age ^b (years)	Sex	Strontium-90 concentration (pCi/kg bone)	Calcium concentration (g/kg bone)	⁹⁰ Sr/Ca (pCi/g)
Northeast:						
Pennsylvania.....	V	01	M	112.0 ± 02.0 *	25.0	4.48
New York.....	V	02	M	119.0 ± 13.0	22.8	5.21
Vermont.....	V	03	F	152.0 ± 9.2	33.5	4.67
New York.....	V	05	M	86.1 ± 11.0	31.8	2.77
Massachusetts.....	V	06	F	137.0 ± 11.0	30.9	4.43
New York.....	V	06	M	86.1 ± 8.3	27.2	3.18
New York.....	V	06	M	86.1 ± 7.9	27.1	2.37
Vermont.....	V	07	F	208.0 ± 13.0	45.9	4.53
New York.....	V	07	F	60.3 ± 8.7	34.7	2.90
Pennsylvania.....	V	08	M	236.0 ± 23.0	147.0	1.53
Connecticut.....	V	08	M	78.5 ± 12.0	29.6	2.63
Pennsylvania.....	V	08	F	62.3 ± 6.6	29.2	2.13
Maine.....	V	09	M	127.0 ± 15.0	37.3	3.40
Massachusetts.....	V	10	F	120.0 ± 10.0	43.1	2.85
Massachusetts.....	V	11	F	109.0 ± 13.0	40.4	2.97
New York.....	V	12	F	167.0 ± 11.0	43.4	2.54
New York.....	V	13	F	144.0 ± 14.0	58.2	2.86
Massachusetts.....	V	14	M	130.0 ± 8.9	37.4	3.55
Connecticut.....	V	14	M		33.6	4.13
Connecticut.....	V, R	14	F	85.1 ± 8.8	38.2	2.17
Massachusetts.....	V	15	F	200.0 ± 9.5	44.3	4.51
Massachusetts.....	V	16	M	120.0 ± 9.7	42.3	2.83
Vermont.....	V	16	M	66.0 ± 8.7	46.4	1.43
Connecticut.....	V, R	16	M	148.0 ± 10.0	45.1	3.28
New York.....	V, R	17	M	171.0 ± 12.0	82.2	2.08
Connecticut.....	V, R	17	M	286.0 ± 21.0	64.5	4.43
New York.....	V	18	M	126.0 ± 11.0	47.7	2.85
Massachusetts.....	V	19	F	114.0 ± 11.0	41.6	2.74
Massachusetts.....	V	19	M	115.0 ± 12.0	50.6	1.06
New York.....	V	19	M	120.0 ± 16.0	56.3	2.30
Connecticut.....	V, R	20	M	115.0 ± 12.0	43.9	2.61
Connecticut.....	V, R	20	F	63.7 ± 8.3	45.1	1.41
New York.....	V	20	M	106.0 ± 9.5	46.9	2.36
New York.....	V	20	M	80.6 ± 9.3	32.7	2.46
Connecticut.....	V	20	M	106.0 ± 12.0	61.0	1.72
Massachusetts.....	V	23	M	82.5 ± 8.4 *	40.6	2.03
Connecticut.....	V	23	M	63.9 ± 6.9	42.6	1.50
New York.....	V	23	M	121.0 ± 21.0	50.8	2.38
Massachusetts.....	V	25	M	71.2 ± 10.0	40.3	1.76
New York.....	V	25	M	64.9 ± 8.9	42.9	2.21
Southeast:						
North Carolina.....	V	01	M	150.0 ± 30.0	25.2	5.95
South Carolina.....	V	01	M	137.0 ± 24.0	32.4	4.22
North Carolina.....	V	01	M	143.0 ± 18.0	30.6	5.03
Maryland.....	V	02	M	147.0 ± 26.0	36.4	4.03
Maryland.....	V	02	M	147.0 ± 23.0	29.3	5.01
North Carolina.....	V	02	F	177.0 ± 26.0	20.0	8.85
North Carolina.....	V	03	F	197.0 ± 31.0	23.0	8.56
South Carolina.....	V	04	F	143.0 ± 21.0	29.1	4.91
Maryland.....	V	05	F	177.0 ± 25.0	37.0	4.78
Maryland.....	V	06	F	93.5 ± 19.0	30.5	3.06
Maryland.....	V	06	M	78.4 ± 12.0	34.3	2.28
Maryland.....	V	07	M	122.0 ± 14.0	37.5	3.25
South Carolina.....	V	07	M	107.0 ± 12.0	37.6	2.84
Maryland.....	V	08	M	63.6 ± 10.0	38.1	1.66
Maryland.....	V	08	F	75.7 ± 16.0	39.4	1.92
Georgia.....	V	08	F	60.8 ± 14.0	26.3	2.31
South Carolina.....	V	09	F	245.0 ± 39.0	36.2	6.76
Maryland.....	V	11	F	104.0 ± 8.5	40.3	2.58
South Carolina.....	V, M	11	F	215.0 ± 16.0	46.7	4.60
North Carolina.....	V	14	M	94.3 ± 9.0	42.8	2.23
Georgia.....	V	14	M	86.5 ± 11.0	37.4	2.36
North Carolina.....	V	15	F	128.0 ± 18.0	49.3	4.01
South Carolina.....	V	15	F	85.8 ± 15.0	55.0	1.56
Maryland.....	V	16	M	127.0 ± 12.0	46.9	2.70
Maryland.....	V	16	M	115.0 ± 12.0	64.4	1.78
Maryland.....	V	16	M	177.0 ± 17.0	55.3	3.20
Maryland.....	V	16	M	253.0 ± 25.0	55.9	4.52
North Carolina.....	V	16	M	160.0 ± 14.0	46.2	3.46
Maryland.....	V	17	M	157.0 ± 16.0	57.5	2.73
Georgia.....	V	17	M	146.0 ± 21.0	51.6	2.82
Kentucky.....	V	17	F	98.0 ± 13.0 *	67.6	1.46
Maryland.....	V	18	M	216.0 ± 21.0	50.7	4.26
Maryland.....	V	18	M	138.0 ± 12.0	64.7	2.52
North Carolina.....	V	19	M	192.0 ± 22.0	48.9	3.92
Georgia.....	V	19	F	172.0 ± 13.0	50.2	3.42
Maryland.....	V	20	M	114.0 ± 15.0	66.7	1.70
Maryland.....	V	20	M	93.9 ± 10.0	47.2	1.98
Maryland.....	V	20	F	122.0 ± 13.0	53.6	2.27
Virginia.....	V	20	M	154.0 ± 22.0	67.8	2.27

See footnotes at end of table.

Table 1. Strontium-90 in human bone, April-June 1968—Continued

Bone region and State of residence	Bone type *	Age ^b (years)	Sex	Strontium-90 concentration (pCi/kg bone)	Calcium concentration (g/kg bone)	⁹⁰ Sr/Ca (pCi/g)
Southeast: (Continued)						
Maryland.....	V	21	M	136.0 ± 25.0	53.0	2.56
Maryland.....	V	21	M	139.0 ± 16.0	53.3	2.60
North Carolina.....	V	21	M	147.0 ± 37.0	55.2	2.66
North Carolina.....	V	21	M	134.0 ± 18.0	50.0	2.68
Maryland.....	V	22	M	101.0 ± 13.0	54.3	1.86
Maryland.....	V	22	M	149.0 ± 21.0	53.3	2.79
Maryland.....	V	22	M	123.0 ± 19.0	51.8	2.37
Georgia.....	V	23	M	178.0 ± 30.0	62.0	2.87
Maryland.....	V	24	M	187.0 ± 16.0	58.8	3.18
Maryland.....	V	24	M	64.2 ± 13.0	52.3	1.22
Maryland.....	V	24	M	92.5 ± 18.0	65.1	1.42
Maryland.....	V	25	M	67.9 ± 14.0	60.0	1.13
Maryland.....	V	25	M	120.0 ± 16.0	53.2	2.25
Maryland.....	V	25	F	187.0 ± 22.0	62.0	3.01
North Carolina.....	V	25	F	52.8 ± 33.0	40.4	1.30
South Carolina.....	V	25	M	66.2 ± 8.9	49.5	1.33
South Carolina.....	V	25	F	90.3 ± 13.0	36.0	2.50
Central:						
Wisconsin.....	V	00	M	84.4 ± 20.0	34.4	2.45
Ohio.....	V	00	M	103.0 ± 16.0	26.6	3.87
Wisconsin.....	V	01	M	181.0 ± 24.0	40.8	4.43
Wisconsin.....	V	01	F	120.0 ± 17.0	32.6	3.68
Wisconsin.....	V	01	M	65.0 ± 12.0	27.1	2.39
Wisconsin.....	V	01	M	103.0 ± 17.0	28.7	3.58
Wisconsin.....	V	01	F	91.6 ± 14.0	31.5	2.90
Wisconsin.....	V	01	F	93.1 ± 18.0	22.3	4.17
Wisconsin.....	V	01	F	159.0 ± 25.0	31.3	5.07
Indiana.....	V	02	M	149.0 ± 25.0 *	40.8	3.65
Ohio.....	V	02	M	82.2 ± 22.0	37.0	2.22
Wisconsin.....	V	04	M	184.0 ± 16.0	36.6	5.02
Michigan.....	V	04	M	105.0 ± 19.0	34.0	3.08
Ohio.....	V	04	F	42.9 ± 18.0	29.0	1.47
Iowa.....	V	04	M	91.1 ± 14.0	32.1	2.83
Illinois.....	V	06	M	147.0 ± 16.0	35.4	4.15
Wisconsin.....	V	06	F	74.2 ± 10.0	40.1	1.85
Wisconsin.....	V	06	F	65.2 ± 10.0	28.0	2.32
Wisconsin.....	V	06	M	133.0 ± 11.0	31.7	4.19
Ohio.....	V	08	M	132.0 ± 11.0	30.9	4.27
Ohio.....	V	09	F	77.5 ± 10.0	31.4	2.46
Ohio.....	V	10	F	113.0 ± 12.0	38.0	2.97
Wisconsin.....	V	10	M	143.0 ± 24.0	58.5	2.44
Ohio.....	V	11	M	58.6 ± 8.8	35.5	1.65
Wisconsin.....	V	15	F	111.0 ± 13.0	41.4	2.68
Michigan.....	V	16	M	175.0 ± 18.0	71.6	2.44
Ohio.....	V	17	M	237.0 ± 21.0	65.2	3.68
Ohio.....	V	17	M	125.0 ± 19.0	48.5	2.74
Wisconsin.....	V	17	M	92.1 ± 14.0	56.9	1.61
Ohio.....	V	19	F	96.2 ± 16.0	68.0	1.41
Ohio.....	V	19	M	66.1 ± 13.0	42.0	1.57
Wisconsin.....	V	20	M	136.0 ± 26.0	62.3	2.18
Ohio.....	V	21	M	164.0 ± 11.0	61.1	2.68
Ohio.....	V	21	F	70.1 ± 11.0	53.1	1.32
Minnesota.....	V	24	F	92.4 ± 26.0	74.7	1.23
Ohio.....	V	25	F	160.0 ± 22.0	75.5	1.98
Ohio.....	V	26	F	75.3 ± 32.0	68.9	1.09
Delta:						
Louisiana.....	V, R	03	M	227.0 ± 20.0	39.2	5.79
Louisiana.....	V	04	M	78.4 ± 14.0	20.3	3.95
Louisiana.....	V	04	M	54.9 ± 14.0	20.3	2.70
Louisiana.....	V	06	F	97.3 ± 18.0	25.9	3.75
Louisiana.....	V, R	10	M	62.6 ± 13.0	33.2	1.88
Louisiana.....	V	12	F	125.0 ± 23.0	46.3	2.69
Louisiana.....	V, R	18	M	138.0 ± 19.0	60.0	2.30
Louisiana.....	V	02	M	157.0 ± 24.0 *	47.4	3.31
Northwest:						
Oregon.....	V	01	M	85.5 ± 13.0	29.1	2.93
Oregon.....	V	02	M	122.0 ± 11.0	34.3	3.55
Oregon.....	V	04	F	126.0 ± 9.9	29.2	4.31
Washington.....	V	06	F	157.0 ± 14.0	32.6	4.81
Washington.....	V	18	M	200.0 ± 12.0	78.9	2.53
Oregon.....	V	20	M	214.0 ± 22.0	85.1	2.51
Ohio.....	V	21	M	131.0 ± 9.6	55.9	2.34
Oregon.....	V	24	M	174.0 ± 18.0	65.0	0.84
Oregon.....	SK	24	M	51.2 ± 9.1	52.7	0.97
Oregon.....	V	24	M	43.1 ± 7.2	48.8	0.88
Washington.....	V	24	M			
Southwest:						
Texas.....	V	03	F	62.3 ± 17.0	27.9	2.23
Texas.....	V	04	M	81.1 ± 15.0	26.8	3.02
Texas.....	V	09	M	70.1 ± 14.0	27.0	2.50
Colorado.....	V	11	F	115.0 ± 11.0	42.2	2.72
Colorado.....	V	16	M	77.7 ± 7.4	47.8	1.62
Colorado.....	V	19	M	61.7 ± 9.0	59.6	1.03
California.....	V	20	F	60.2 ± 12.0	43.7	1.37
Texas.....	V	20	F			

* Type of bone: V, vertebrae; R, rib; S, sternum; SK, skull

^b Age given as of last birthday prior to death.

* Two-sigma counting error

Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the National Center for Radiological Health, at Winchester, Mass. Sample collection and preparation are explained elsewhere (2). Strontium-90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated (3) from the yttrium-90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. To further check and maintain analytical accuracy, synthetic "bone ash" samples (calcium phosphate spiked with strontium-90) are analyzed periodically and crosscheck analyses are carried out quarterly with the Health and Safety Laboratory of the AEC, which performs similar analyses.

The analytical results for strontium-90 in individual bones from persons dying during the second quarter (April-June) of 1967 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium-90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with

other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (2-5).

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
October-December 1966	September 1967
January-March 1967	June 1968

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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Opera-

tional Safety in directives published in the AEC Manual.¹

Summaries of data from the environmental radioactivity monitoring reports follow for the Lawrence Radiation Laboratory and Mound Laboratory.

¹ Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Lawrence Radiation Laboratory
July-December 1967²

University of California
Berkeley, California

Berkeley Site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is situated on the western slope of the range of hills running along the eastern side of San Francisco Bay. The laboratory is largely separate from the main campus of the University, although there is some overlap (figure 1).

To the north and south of the laboratory area are residential areas of the cities of Berkeley and Oakland. The Berkeley campus of the University of California is on the west; to the east, are the Lawrence Hall of Science and the Space Sciences Laboratory, beyond them lies uninhabited watershed land and the Tilden Regional Park.

The most prevalent wind direction is westerly. During the summer months the afternoon sea breeze establishes a very pronounced prevailing westerly wind direction. At other times, the direction is less predictable. Annual rainfall is 23 inches, almost all of which falls between November 1 and May 1. The prevailing wind direction during precipitation is southerly.

The laboratory carries on a wide ranging program of general research in the fields of both physical and biological sciences. Facilities include a number of large accelerators, and various physics, chemistry, biology and medical research laboratories.

The basic policy at LRL has long been to prevent, as far as possible, any release of radioactive material to the environment, no matter how small. No deliberate releases are sanctioned, except where no practical method for containment has yet been developed and quantities are small compared with standards established by the ICRP and AEC.

The most sensitive measurements of releases are those taken closest to the source itself,

before dilution makes detection of small quantities more difficult. The stack sampling program, therefore, provides the most useful information for controlling releases to the atmosphere. Over 100 separate exhausts from hoods and glove box manifolds are sampled. The total quantities released from these stacks during the 6 months were 0.1 microcuries of alpha-particle emitters and 400 microcuries of beta-particle emitters. The average concentrations in the total exhaust, before any dilution by the atmosphere, was 7 percent of the maximum permissible concentration for offsite breathing zone air, as given by the ICRP.

In addition to the careful sampling of stacks, an environmental air sampling program is also carried on to make sure no undetected releases occur. These samples provide a direct measurement of possible exposure to the nearby population. The sampling stations designated "local area" are scattered around the site and provide samples of the atmosphere on the site itself. The "perimeter" samples are taken at the boundary line of University property, in the direction of populated areas. From the results of these samples, it is apparent that there has been no significant exposure from radioactive materials released by LRL. The levels of radioactivity observed in each type of sample are presented in table 1.

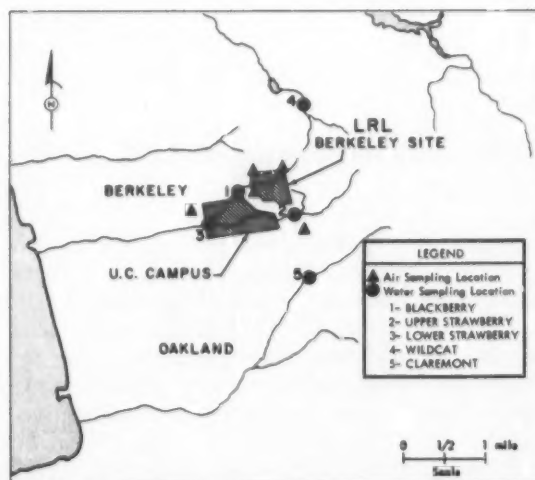


Figure 1. Environmental sampling locations at the Berkeley site

² Summarized from "Results of Environmental Radioactivity Sampling Program July-December 1967," Lawrence Radiation Laboratory, Livermore and Berkeley, Calif.

**Table 1. Atmospheric monitoring, LRL Berkeley site
July-December 1967**

Sampling locations (number of locations)	Number of samples	Concentration (pCi/m ³)			
		Alpha radioactivity		Beta radioactivity	
		Average	Max- imum	Average	Max- imum
Local area (10).....	258	0.000	0.008	0.02	0.20
Perimeter (4).....	101	.001	<.005	.04	.24

At each of these environmental stations rain or dry "fallout" is also collected. Open 15-inch diameter polyethylene bags form the collecting vessel. If no rain has fallen, the bags are rinsed out with dilute nitric acid. Results from these collections show a lot of variation, without any consistent pattern. Since on the average, the more remote perimeter stations show about the same radioactivity as the nearer ones, it must be assumed that the radioactivity does not result from laboratory operations. The radioactivity levels in samples collected at each location are summarized in table 2.

**Table 2. Total deposition, LRL Berkeley site
July-December 1967**

Sampling locations (number of locations)	Number of samples	Deposition (nCi/m ²)			
		Alpha radioactivity		Beta radioactivity	
		Average	Max- imum*	Average	Max- imum*
Local area (9).....	47	0.10	6.39	1.27	1.85
Perimeter (4).....	21	.11	.15	1.24	1.89

* Maximum deposition at a single location for the 6-month period.

All liquid waste known to be radioactive is collected, solidified, and shipped away. Other liquid wastes are discharged directly to the municipal sewer system. Occasionally, small quantities of radioisotopes are accidentally released to the sewer system. There are two outfalls, each of which is monitored by a continuous proportional sampling system to insure that no significant quantities have been discharged. The total concentration (alpha plus beta radioactivity) in sewage is only 25 percent of the standard for drinking water and

therefore does not constitute a serious exposure threat. A sizeable fraction of the measured beta concentration is the naturally occurring isotope potassium-40 from human wastes and chemicals.

The storm drainage from the laboratory flows into the surface stream system. These surface streams are exposed as they run through the University property and are sampled at three places. Results are listed as "onsite streams" in the table. Two nearby off-site streams are also sampled to provide a comparison. No alarming concentrations have been observed. All are safely below the standard for drinking water. The results from the water sampling program are presented in table 3.

**Table 3. Water monitoring, LRL Berkeley site
July-December 1967**

Type and source of sample	Number of samples	Concentration (pCi/liter)			
		Alpha radioactivity		Beta radioactivity	
		Average	Max- imum	Average	Max- imum
Sewage:					
Hearst sewer.....	26	0.8	5.6	25.7	47.0
Strawberry sewer.....	26	.3	2.7	10.7	47.0
Tap water.....	24	.01	.44	2.00	3.6
Surface water:					
Onsite streams.....	78	.5	4.8	8.4	47.8
Offsite streams.....	82	.9	5.8	2.4	6.4

Neutron and gamma-ray fields are measured at each of the four perimeter stations as well as at several locations within the site. Background measurements are obtained from a leased building used as a low level counting room in downtown Berkeley. This building is remote from the main LRL site and measurements are not influenced by accelerator operations.

Levels were somewhat higher than they were during the first 6 months of the year due to the resumption of Bevatron operations. However, the radiation levels were well below the standards set for the general public by the ICRP and NCRP.

Livermore site

The Livermore site of LRL (figure 2) is located in the Livermore Valley midway be-

tween the Pacific coast and the San Joaquin Valley in northern California—approximately 50 miles southeast of San Francisco. Shielded from the ocean by the western hills, the Livermore Valley has a warm, dry climate. Annual rainfall is about 14 inches and the relative humidity is about 30 percent during the summer months and about 40-50 percent the remainder of the year. Prevailing winds are from the west, but inversions are frequent during the night. Technical facilities include a small cyclotron, a 2-megawatt swimming pool reactor, and physics and chemistry programs associated with a weapons development program.

Agriculture is the principal activity in the Livermore Valley. Roses, grain, hay, and grapes are the major products. Several cattle and sheep ranches surround the Livermore site.

The Livermore site comprises an area of 1-square mile, approximately 3 miles east of the city of Livermore. Livermore and Pleasanton, with a combined population of 45,000, are populated areas of primary interest to the Livermore site.

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air

particulates, soil, domestic water, sewer effluent, sewage plant products, milk, and vegetation. The milk samples are obtained from two dairies in the Livermore Valley and one in another valley about 25 miles away, which is used as a check. The water samples are collected to monitor radioactivity in an underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton, and is the sole supply for ranches in the Livermore and Amador Valleys.

Air samples are collected continuously at 15 sites within 5 miles of the laboratory. Samples are collected at a rate of 4 cfm on 100-square centimeter HV-70 filter papers, which are changed after every 7 days of operation. A minimum decay period of 96 hours is observed before the samples are counted to eliminate the effect of natural radon and thoron daughters. All environmental air samples are counted in an automated system which utilizes gas flow proportional detectors for both alpha and beta radioactivity measurements. Alpha radioactivity in 450 air samples collected from 16 sampling locations averaged less than 0.001 pCi/m³. The average beta radioactivity was lower than the average for last year—0.02 pCi/m³ (1967), versus 0.05 pCi/m³ (1966). The applicable AEC radiation protection standards are 0.040 pCi/m³ for alpha-particle emitters and 1 pCi/m³ for beta-particle emitters.

The measurement of low level "background" radiation during this period was accomplished with thermoluminescent dosimeters located at nine points on the site perimeter and at two nearby ranches. The limit of detection for these dosimeters is 20 mR. One dosimeter at a point opposite cobalt-60 irradiation facility recorded 150 mR for the 6-month period. One dosimeter opposite an experimental physics facility recorded 20 mR. All others were below the limit of sensitivity or less than 0.005 mR/hr.

Domestic water samples were collected monthly from nine nearby sources. No sample showed an alpha specific radioactivity above the limit of sensitivity (5.0 pCi/liter). The beta radioactivity fluctuated from the limit of sensitivity (1.8 pCi/liter) to 14 pCi/liter. The average beta radioactivity concentration was 3.3 pCi/liter. The average alpha and beta radioactivity concentrations were below the re-

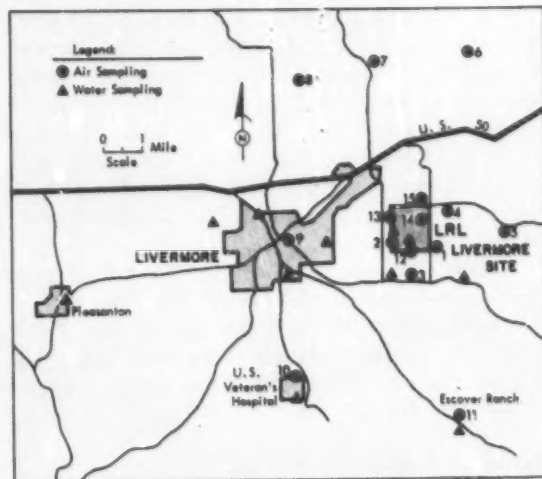


Figure 2. Environmental sampling locations at the Livermore site

spective standards of comparison of 10 and 100 pCi/liter stated in AEC standards.

The average tritium content was at or below the limit of sensitivity (5,000 pCi/liter), which is well below the standard of comparison of 3×10^5 pCi/liter.

Samples were collected daily at the laboratory sewer discharge. The average concentration of radionuclides in the sewer effluent was 30 ± 3 pCi/liter of alpha radioactivity and 81 ± 8 pCi/liter of beta radioactivity. The standard of comparison is 300 pCi/liter for both alpha and beta radioactivity. The tritium content of the effluent was 3.9×10^4 pCi/liter.

Samples of top layer soil are collected quarterly at the 19 sampling stations surrounding the Livermore site. The alpha radioactivity fluctuated from the limit of sensitivity (1.5 pCi/g) to 11 pCi/g. The beta radioactivity fluctuated from the limit of sensitivity (3.5 pCi/g) to a single sample high of 13 pCi/g. The average alpha radioactivity was 2.0 pCi/g and the average beta radioactivity was 7.0 pCi/g. The concentrations detected are within the normal range for soil in the Livermore Valley.

Average radioactivity levels in monthly milk samples amounted to 4 pCi/liter of cesium-137 and 10 pCi/liter of cerium-141-144, for the two Livermore dairies. The average tritium concentration in milk was at or below the limit of sensitivity (5,000 pCi/liter).

Site 300

The high explosive test area at Site 300 (figure 3) covers 10 square miles in the hills in a very sparsely populated ranching area about 15 miles southeast of Livermore and 8 miles southwest of Tracy. The chief area of concern for Site 300 is Tracy. The population there is about 15,000. Air and water samples are taken to determine whether operations at Site 300 are changing the normal radioactivity levels in the vicinity. The eight air samplers at Site 300 are operated at about 50 cfm on a continuous basis with the filter papers being changed on regular schedule. Most of these air samplers are located within the boundaries of the test site due to unavailability of power

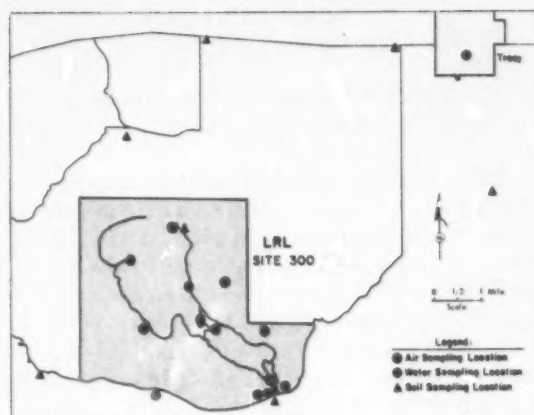


Figure 3. Sampling locations at Site 300, LRL

facilities offsite. Water samples are taken from six onsite wells because they are the only readily accessible sources of underground water. Two samples showed an alpha radionuclide concentration above the limit of sensitivity (5.0 pCi/liter) one at 90 pCi/liter and one at 61 pCi/liter. Resampling showed these locations to be below the limit of sensitivity during processing is suspected. All others were below the limit of sensitivity. The beta concentrations ranged from the limit of sensitivity (1.8 pCi/liter) to 33 pCi/liter, averaging 5.5 pCi/liter. Samples are collected from streams only during the winter months when water flow exists. Soil samples are collected quarterly at nine offsite locations. Only top layer soil is collected to determine fallout concentrations. All air, water, and soil samples are processed at the laboratory in Livermore. The average radioactivity levels in samples collected are summarized in table 4.

Table 4. Environmental sampling, Site 300
July-December 1967

Type of sample (concentration units)	Average alpha radioactivity	Average beta radioactivity
Air (pCi/m ³).....	0.0004	0.024
Water (pCi/liter).....	<5.0	5.5
Soil (pCi/g).....	6	6

Recent coverage in Radiological Health Data and Reports:

Period	Issue
July-December 1966	November 1967
January-June 1967	April 1968

2. Mound Laboratory July-December 1967¹

Monsanto Research Corporation
Miamisburg, Ohio

The environmental monitoring program for Mound Laboratory is planned and coordinated with all the projects conducted at the laboratory. Air and water monitoring in the uncontrolled environs surrounding the laboratory is specific for the radionuclides which could be released to the environment. Only polonium-210, plutonium-238, and hydrogen-3 (tritium) are potential environmental contaminants.

Air monitoring

Mobile air monitoring equipment, mounted on a 1-ton panel truck, for measurement of tritium and collection of particulate alpha-particle emitters was used in the routine monitoring of environmental air in a network of 111 locations within a radius of 20 miles from the laboratory during the collection period. The choice of sites on a given day was dependent upon the wind direction at the time of collection.

Airborne polonium and plutonium particulates are collected with a high volume air sampler. The filter papers are then processed such that counting results are specific for polonium and plutonium. One fourth of each filter paper is processed by spontaneous deposition to isolate polonium. Plutonium is isolated by processing the remaining three fourths of each filter paper through a resin column.

Prior to August 22, 1967, airborne tritium was monitored by drawing air through a calcium chloride drying tube and then analyzing the collected moisture for tritium. Beginning August 22, 1967, the procedure was changed to bubbling an air sample through a liquid scintillation counting solution with p-dioxane as the organic solvent. The counting solution is then counted directly in a liquid spectrometer.

Beginning January 1, 1967, all particulate air samples collected in the same zone, in the

same range, and on the same day are combined before processing and are considered as one sample. This is done to improve the lower detectable limit for plutonium.

The results of the airborne monitoring program are presented in tables 5, 6 and 7. The average concentrations of plutonium, polonium, and tritium in the environment are below the AEC radiation protection standards.

Table 5. Atmospheric monitoring of polonium-210, Mound Laboratory environs, July-December 1967

Range (miles)	Number of samples	Concentration * (pCi/m ³)		Average as percent of AEC standards ^b
		Maximum	Average	
0-3 (upwind).....	21	0.6690	0.0159	0.26
0-3 (downwind).....	21	.0320	.0173	.09
3-5 (downwind).....	21	.6882	.0561	.28
5-10 (downwind).....	21	.0991	.0315	.16
10-15 (downwind).....	21	.0600	.0259	.13
15-20 (downwind).....	21	.0366	.0179	.09

* Lowest detectable level (LDL) for polonium-210 in air is 0.0080 pCi/m³ for samples collected 0-3 miles upwind, 3-5 miles downwind, 5-10 miles downwind, and 10-15 miles downwind. The LDL is 0.0053 pCi/m³ for samples collected 0-3 miles downwind and 15-20 miles downwind. All values which were not detectable were set equal to these values when average values were calculated.

^b The applicable AEC radiation protection standard for polonium-210 in air is 20 pCi/m³.

Table 6. Atmospheric monitoring of plutonium-238, Mound Laboratory environs, July-December 1967

Range (miles)	Number of samples	Concentration * (pCi/m ³)		Average as percent of AEC standards ^b
		Maximum	Average	
0-3 (upwind).....	21	0.0264	0.0069	0.86
0-3 (downwind).....	21	.0605	.0082	11.71
3-5 (downwind).....	21	.1114	.0148	21.14
5-10 (downwind).....	21	.0142	.0081	8.71
10-15 (downwind).....	21	.0984	.0120	17.14
15-20 (downwind).....	21	.0273	.0058	8.29

* Lowest detectable limit (LDL) for plutonium-238 in air is 0.0013 pCi/m³ for samples collected 0-3 miles upwind, 3-5 miles downwind, 5-10 miles downwind and 10-15 miles downwind. The LDL is 0.0009 pCi/m³ for samples collected 0-3 miles downwind and 15-20 downwind. All values which were not detectable were set equal to these values when average values were calculated.

^b The applicable AEC radiation protection standard for plutonium-238 in air is 0.07 pCi/m³.

Table 7. Atmospheric monitoring of tritium, Mound Laboratory environs, July-December 1967

Range (miles)	Number of samples	Concentration * (pCi/m ³)		Average as percent of AEC standards ^b
		Maximum	Average	
0-3 (upwind).....	20	25.00x10 ³	0.98x10 ³	4.54
0-3 (downwind).....	19	26.90x10 ³	9.30x10 ³	4.65
3-5 (downwind).....	19	10.55x10 ³	8.13x10 ³	4.07
5-10 (downwind).....	18	10.69x10 ³	8.15x10 ³	4.08
10-15 (downwind).....	17	8.00x10 ³	8.00x10 ³	4.00
15-20 (downwind).....	16	9.40x10 ³	8.08x10 ³	4.04

* Lowest detectable limit for tritium in air is 8x10³ pCi/m³. All values which were not detectable were set equal to this value when average values were calculated.

^b The applicable AEC radiation protection standard for tritium in air is 2x10³ pCi/m³.

¹ Summarized from "Environmental Monitoring Report," July-December 1967 and 1967 summary (MLM-1464).

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed in special waste disposal plants designed to reduce radioactivity to a concentration at which it may be discharged to the Great Miami River.

Helium-3, which is purified at the Mound Laboratory, contains small quantities of hydrogen-3 (tritium). Liquid wastes from this operation are treated separately to assure that the radioactivity level is below the AEC radiation protection standard before discharge to the Great Miami River.

Weekly water samples are collected from a drainage ditch and six locations along the Great Miami River as shown in figure 4. Additional samples are taken quarterly at more distant downstream points. The drainage ditch carries all storm sewer water and treated liquid tritium and plutonium wastes from the plant site. Sampling location number 3 (figure 4) is the point of discharge of the liquid polonium waste to the Great Miami River, and number 7, at Franklin, Ohio, is 5 miles downstream from the effluent outfall.

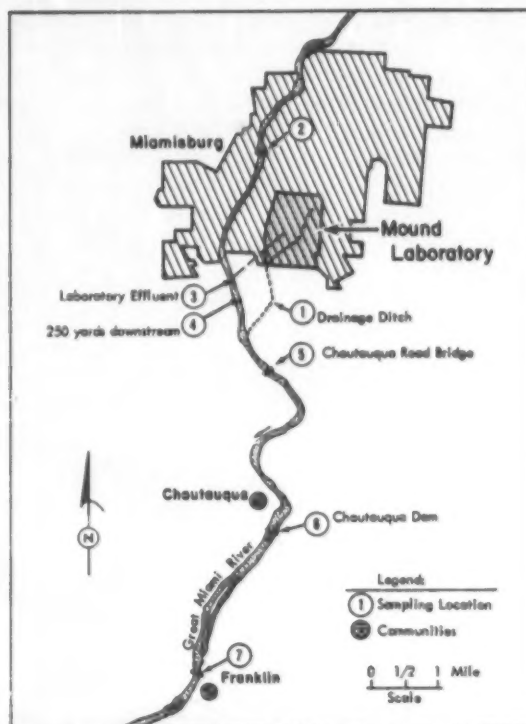


Figure 4. Water sampling locations, Mound Laboratory

Table 3. Offsite water monitoring for radioactivity, Mound Laboratory environs, July-December 1967

Nuclide and sampling location ^a	Number of samples	Concentration (pCi/liter)	
		Maximum	Average ^b
Polonium-210 ^c			
2 (Upstream from laboratory).....	23	* 1.80	* 1.80
3 (Laboratory effluent).....	23	1,180.18	86.89
4 (250-yards downstream).....	23	* 1.80	* 1.80
5 (Chautauqua Road Bridge).....	23	7.21	2.03
6 (Chautauqua Dam).....	23	4.50	1.94
7 (Franklin, Ohio).....	23	* 1.80	* 1.80
Hydrogen-3 (tritium) ^c			
1 (drainage ditch).....	23	1.80x10 ^e	0.22x10 ^e
2 (Upstream from laboratory).....	23	0.63x10 ^e	.08x10 ^e
3 (Laboratory effluent).....	23	16.00x10 ^e	.97x10 ^e
5 (Chautauqua Road Bridge).....	23	.08x10 ^e	* .05x10 ^e
Plutonium-238 ^c			
1 (drainage ditch).....	23	23,423.42	1,565.32
2 (Upstream from laboratory).....	23	324.32	18.47
3 (Laboratory effluent).....	23	1,279.28	101.35
4 (250-yards downstream).....	23	18.02	5.41
5 (Chautauqua Road Bridge).....	23	207.21	13.51
6 (Chautauqua Dam).....	23	* 4.50	* 4.50
7 (Franklin, Ohio).....	23	9.01	4.95

^a See figure 4 for number of sampling locations.

^b The applicable AEC radiation protection standards for uncontrolled areas are as follows:

Polonium-210 in water: 7x10 ⁻⁴ pCi/liter.

Hydrogen-3 in water: 3x10 ⁻⁴ pCi/liter.

Plutonium-238 in water: 5x10 ⁻⁴ pCi/liter.

^c Minimum detectable levels in water are: polonium-210: 1.80 pCi/liter, hydrogen-3: 0.05x10 ⁻⁴ pCi/liter, plutonium-238: 4.50 pCi/liter.

All samples which were not detectable were set equal to their respective minimum detectable level when average values were calculated.

All of the river samples are analyzed for polonium-210 and plutonium-238 and some of the samples are analyzed for tritium. The drainage ditch samples are analyzed for tritium and plutonium-238. Average concentrations of tritium, polonium-210, and plutonium-238 are

given in table 8 for July-December 1967.

Recent coverage in *Radiological Health Data and Reports*:

<u>Period</u>	<u>Issue</u>
July-December 1966 and 1966 summary	November 1967
January-June 1967	April 1968

Reported Nuclear Detonations, August 1968

The U.S. Atomic Energy Commission announced that two nuclear tests of low-intermediate yield (20 to 200 kilotons TNT equiv-

alent) were conducted underground at its Nevada Test Site on August 9 and 29, 1968.

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SYNOPSIS

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

DETECTION OF ELEVATED FALLOUT LEVELS IN CALIFORNIA, JANUARY 1967. Amasa C. Cornish and George Uyecugi. *Radiological Health Data and Reports*, Vol. 8, September 1968, pp. 467-473.

California received a heavy fallout of radioactive debris beginning on December 27, 1966. Highest air particulate levels occurred in Berkeley and Sacramento; values obtained after allowing 3 days decay were 948 pCi/m³ for both. Other air sampling stations had lesser amounts of fallout and Fresno received essentially no fallout. All milksheds in California were contaminated to some extent with radioactive iodine. Del Norte and Humboldt milk with 397 and 280 pCi/liter, respectively, contained the highest concentrations of iodine-131. These values were estimated to result in thyroid doses to children of 33 and 23 mrad, respectively. The apparent half-life for iodine-131 in the environment was calculated to be 3.2 days.

KEYWORDS: California, fallout, foreign nuclear test, iodine-131, milk, thyroid doses.

A COMPARISON OF RESULTS BETWEEN THE PUBLIC HEALTH SERVICE RAW MILK AND PASTEURIZED MILK NETWORKS FOR JANUARY 1964 THROUGH JUNE 1966. Paul B. Robinson. *Radiological Health Data and Reports*, Vol. 9, September 1968, pp. 475-483.

The Public Health Service Raw Milk and Pasteurized Milk Networks are compared for the interval January 1964 through June 1966 on the basis of milk sample analyses made during that period. Once laboratory effects due to analytical differences in the milk sample analyses were removed from the data, the agreement for cesium-137 and strontium-90 between four of the nine stations that were common to both networks was related to milkshed overlap. At two other stations, Cincinnati and Chicago, homogeneity in the agricultural, geographical, and meteorological parameters accounted for the similarity between the sample concentrations of cesium-137 and strontium-90. It was not possible to study iodine-131, barium-140, or strontium-89 because the levels were generally not detectable for the period under study.

A tabulation of data for all samples collected from the Raw Milk Network is also appended for the period January 1963-December 1966.

KEYWORDS: barium-140, calcium, cesium-137, iodine-131, milkshed, pasteurized milk, potassium, raw milk, strontium-89, strontium-90.